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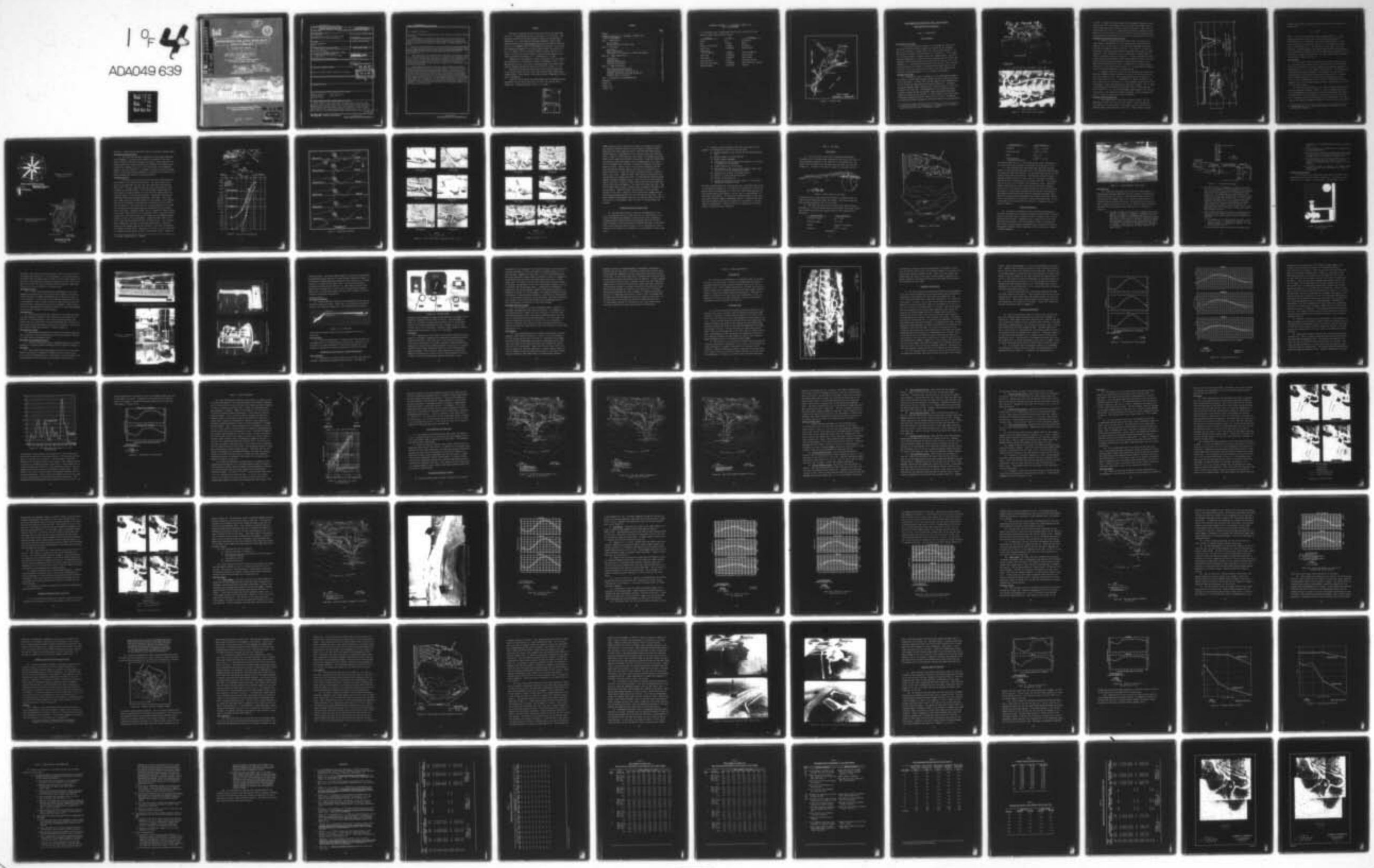

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TECHNICAL REPORT H-77-21

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# IMPROVEMENTS FOR LITTLE RIVER INLET SOUTH CAROLINA.

## Hydraulic Model Investigation.

by

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Little River Inlet, located near the State border of North and South Carolina, is part of the "Grand Strand," a rapidly growing resort area along South Carolina's northeast shore. The inlet is a natural channel through the coastal barrier beach that conducts tidal flows between the Atlantic Ocean, inner channels, and a lagoon approximately 6 square miles in size. The inlet also provides a restricted passage for small-craft navigation from the ocean to
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20. ABSTRACT (Continued).

the Atlantic Intracoastal Waterway (AIWW) and to private and commercial docking facilities.

Improvements for the inlet were authorized on 12 October 1972 and included two jetties, sand transition dikes connecting the structures to the shore, a 300-ft-wide by 12-ft-deep entrance channel through the offshore bar, and a 90-ft-wide by 10-ft-deep inner channel from the entrance channel to the AIWW.

A model study was performed to aid in preconstruction planning and design of the structures and included an investigation of items such as optimum alignment, length and spacing of the jetties, current patterns and magnitudes, sediment movement patterns, effects on the tidal prism, and effects on bay salinities.

The Little River Inlet fixed-bed model, constructed of concrete to scales of 1:300 horizontally and 1:60 vertically, reproduced an area extending to the -40 ft contour in the Atlantic Ocean and to the extent of the influence of the tidal prism on the AIWW. Areas throughout the lagoon were accurately reproduced and model verification tests of tidal elevations, velocities, and salinities assured that the model hydraulic regimes were in satisfactory agreement with the prototype.

Model testing concluded that Plan 2D-1 which included weir sections backed by deposition basins for both jetties would be the most feasible plan. The mean tide level weirs would permit sand transport to the basins on flood tide but would prevent ebb flows from existing over them due to the tidal elevation-velocity relations characteristic of Little River Inlet where maximum ebb velocities occur after the tide elevation has fallen below midtide. Also, flow in the entrance channel was ebb-dominant which would aid in flushing sediment out of the channel. The sand-trapping abilities of the deposition basins permitted shortening of the jetties since a large amount of sand fillet storage would not be needed and sand movement around the jetty tips would be minimized. Testing also indicated there would be no significant change to the bay tidal prism or salinities.

## PREFACE

The model investigation described in this report was authorized by the U. S. Army Engineer District, Charleston, on 23 May 1974. The study was conducted in the Wave Dynamics Division of the Hydraulics Laboratory, U. S. Army Engineer Waterways Experiment Station (WES), during the period July 1974-September 1976 under the general direction of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory. The testing was conducted by members of the Coastal Branch under the direction of Dr. R. W. Whalin, Chief of the Wave Dynamics Division, and Dr. C. L. Vincent, Chief of the Coastal Branch. Testing was performed and this report was prepared by Messrs. W. C. Seabergh and E. F. Lane.

Engineers of the Charleston District responsible for the planning and coordination of the studies included Jack Lesemann, Chief of the Engineering Division, Jerry Durrin, Thurman Morgan, and Lincoln Blake. District Engineer during the study was COL Harry S. Wilson, Jr., CE.

Meetings concerning the model study were attended by personnel of the South Atlantic Division Office and included James Robinson and Richard Bonner. Neill Parker of the Office, Chief of Engineers, OCE was also in attendance.

Directors of WES during the investigation and the preparation and publication of this report were COL G. H. Hilt, CE, and COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

## CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

| Multiply | By | To Obtain |
|---|---|---|
| inches | 25.4 | millimetres |
| feet | 0.3048 | metres |
| miles (U. S. statute) | 1.609344 | kilometres |
| square feet | 0.09290304 | square metres |
| square miles (U. S. statute) | 2.589988 | square kilometres |
| cubic feet | 0.02831685 | cubic metres |
| cubic yards | 0.7645549 | cubic metres |
| feet per second | 0.3048 | metres per second |
| cubic feet per second | 0.02831685 | cubic metres per second |
| degrees (angle) | 0.01745329 | radians |

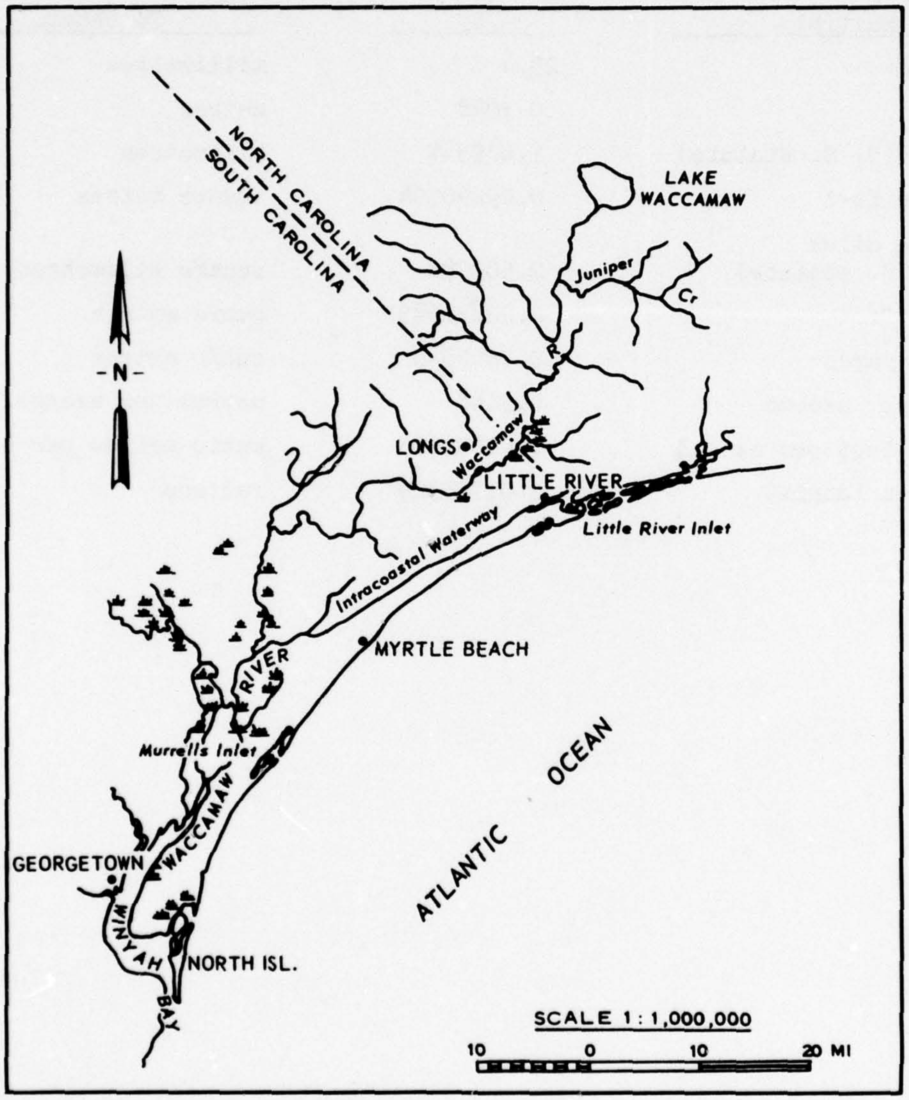


Figure 1. Location map

# IMPROVEMENTS FOR LITTLE RIVER INLET, SOUTH CAROLINA

## Hydraulic Model Investigation

## PART I: INTRODUCTION

### The Prototype

#### Description of the area

1. Little River Inlet, a natural inlet through the coastal barrier beach of North and South Carolina, is located in the northeast portion of the State, 4 miles* east of the town of Little River, S. C., and 23 miles northeast of Myrtle Beach, S. C. (Figure 1). It is a part of the "Grand Strand," a popular resort and vacation region. The inlet provides communication to the ocean from a sheltered bay for charter and commercial fishing boats based at the towns of Little River, S. C., and Calabash, N. C., and private recreational craft as well. The inlet also provides access to the Atlantic Intracoastal Waterway (AIWW) from the ocean and is the only outlet from the AIWW to the ocean between Shallotte, N. C., and Georgetown, S. C., a distance of 73 miles.

#### Navigation problems

2. Although the inlet is unstable and its configuration changes with time, in recent years the main channel has been located on the east side of the inlet. In April 1974, the main channel had a maximum depth of -24 ft mean low water (mlw) at the throat (Figure 2). Oceanward along this channel, depths reduced until a crest of about -6 ft mlw was reached on the outer bar. The combination of the relatively narrow navigable channel and the shallow-bar regions produces difficult and dangerous navigation into the bay. At various times in the recent past, controlling depths have been as shallow as -2.5 ft mlw. An improved and stabilized channel through the inlet and offshore bar was authorized

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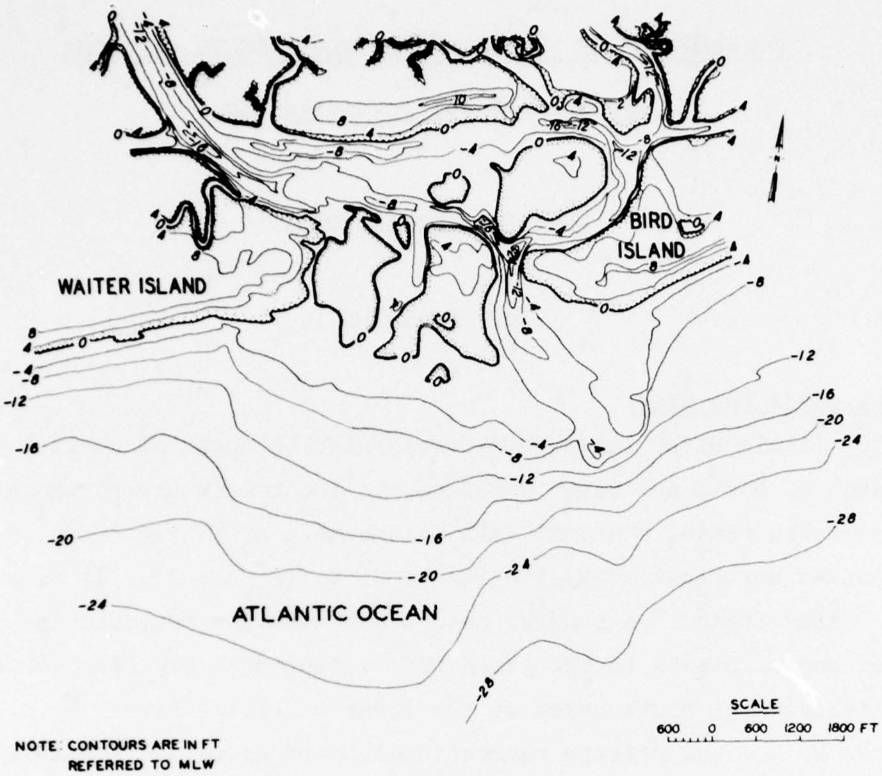
* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.




a. Little River Inlet bathymetry, April 1974

b. Little River Inlet

Figure 2. Little River Inlet planform

in 1965. In August 1967 and November 1968, emergency dredging was performed to provide an 8-ft-deep (at mlw) by 100-ft-wide channel, but in each instance wave action caused a rapid deterioration of this work. A "Survey Report"[1] by the U. S. Army Engineer District, Charleston, recommended a two jetty system with a 12- by 300-ft entrance channel across the seaward bar connected with a 10- by 90-ft inner channel to the AIWW.

<u>Hydraulic and salinity characteristics</u>

3. Based on observations made in April 1974, the inlet has a tidal prism of 505,000,000 cu ft for conditions of a mean ocean tide range of 5.0 ft in the course of a 12.42 hour semidiurnal tidal cycle and with a freshwater inflow of 1200 cfs. Also, there is a source of freshwater flow from the south where the Waccamaw River meets the AIWW (Figure 1). This freshwater inflow is estimated to average 1200 cfs, which is 53,654,400 cu ft per tidal cycle. Salinity observations during a mean tide and mean freshwater inflow have shown the estuary to be well mixed, as bottom salinities normally exceed surface salinities by no more than 25 percent and the ratio of freshwater flow volume during a tidal cycle to the tidal prism was about 0.1. As described by Simmons,[2] these two criteria determine a well-mixed system.

4. Maximum velocities in the inlet throat region for a mean tide and mean freshwater inflow condition are about 2 fps during flood flow and 3 fps during ebb flow. The average tide range in the bay for a 5.0-ft ocean tide is 4.7 ft. The Keulegan $K$ value, a measure of how much a bay fills, is thus equal to 1.3 as determined by the ratio of bay tide range to ocean tide range and by using Dean's[3] graph. The $K$ value as determined by the "current slack method" used by O'Brien and Dean[4] and by Jarrett[5] is 1.1 with the phase angle between high or low tide and slack water at the entrance averaging 28 degrees. Bays associated with this $K$ value are classified as relatively short.

<u>Minimum cross-sectional area</u>

5. The minimum area at the inlets entrance in April 1974 was measured as 11,789 sq ft and the cross section is shown in Figure 3. Also shown is the cross section at the gorge, or the location of the greatest depth, whose area was 15,166 sq ft. Using O'Brien's formula

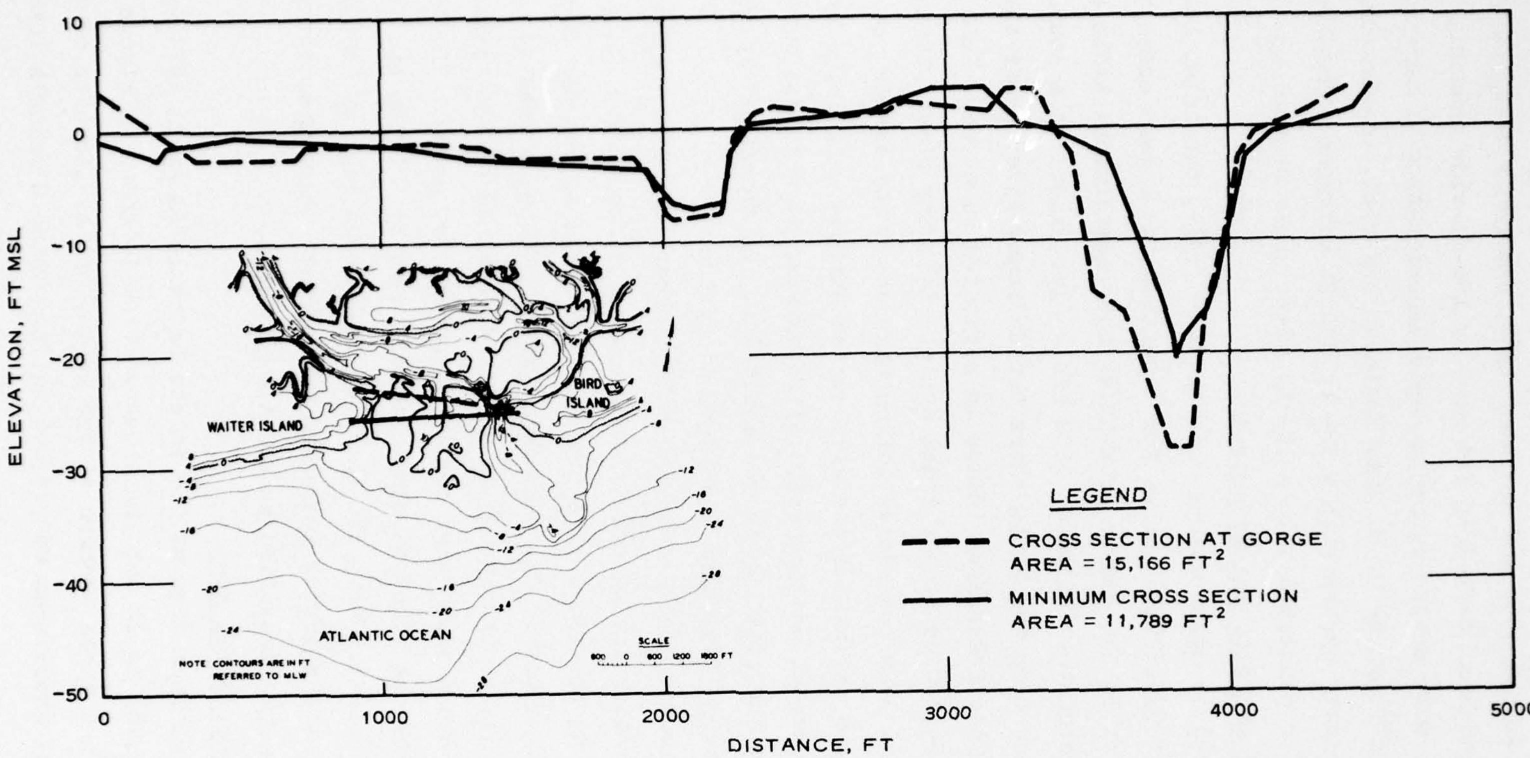



Figure 3. Cross-sectional areas

relating tidal prism to minimum cross-sectional area for a natural unjettied inlet

$$A = 2 \times 10^{-5} P$$

where A is the cross-sectional area in square feet and P is the spring tidal prism in cubic feet, a spring tidal prism equal to 589,450,000 cu ft is calculated. The only prototype data for Little River Inlet are for a mean tide condition of 5 ft ocean with a tidal prism of 505,000,000 cu ft. The spring tide ocean range is 5.9 ft. Therefore, a rough estimate of the spring tidal prism is made by proportion, multiplying 505,000,000 by 5.9/5.0, which equals 595,000,000 cu ft. Therefore, it appears that this inlet fits the O'Brien tidal prism inlet cross-section relation very well.

Wave climate

6. Wave data for the Little River Inlet region of the coast are not unlike most other coastal areas in that detailed directional wave data are not available. A Corps of Engineers wave gage is operated at Holden Beach, N. C., 13 miles upcoast from the inlet. The data* provide only period and height information. For example, for the Sep 1971-Aug 1972 period, the waves at Holden Beach averaged 2.04 ft in height with a standard deviation of 0.90 ft and had an average period of 7.35 sec with a standard deviation of 2.50 sec. Therefore, waves are usually in a 1- to 3-ft height range and vary in period from 5 to 10 sec for this coastal region.

7. Wind data at Charleston, S. C., show the predominant winds are from the south and southwest (Figure 4). This is probably indicative of the predominant wave directions at Little River because the location of Little River Inlet with respect to Frying Pan Shoals at Cape Fear, N. C., provides protection from the winter northeast waves. This can be seen by the refraction diagram of Figure 5 for a 7-sec wave period from

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* Unpublished data, U. S. Army Coastal Engineering Research Center, Fort Belvoir, Virginia.

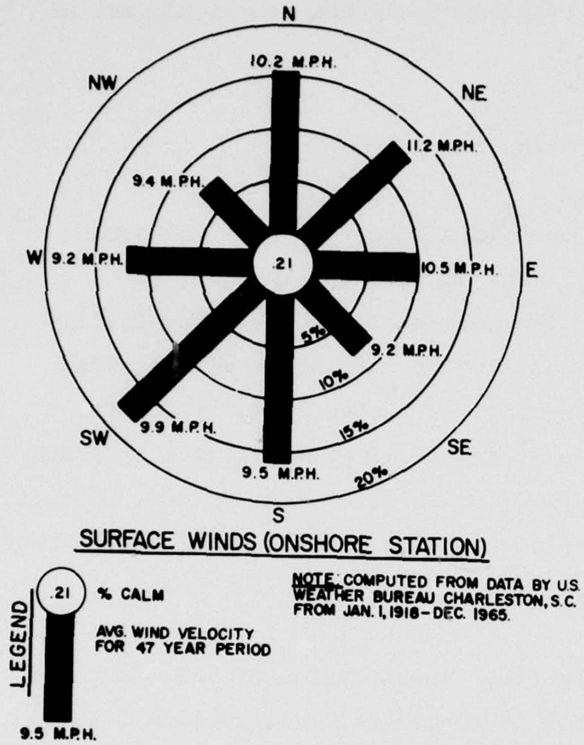


Figure 4. Wind rose, Charleston, S. C.

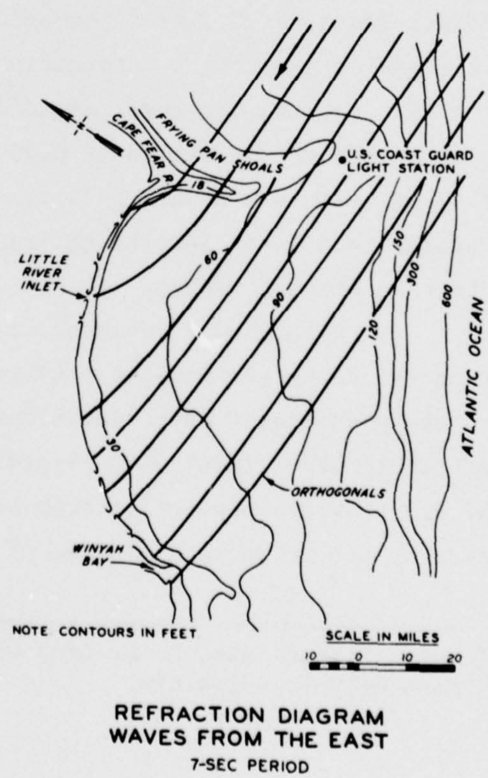


Figure 5. Refraction diagram waves from the east

the east. A wave from the northeast would be refracted a greater amount.

Sedimentary characteristics

8. The inlet cuts through a beachline of silica sand containing shell fragments. Large bar areas (Figure 2b), exposed at low water, span the nearly 3200-ft-wide minimum inlet width. These regions at the entrance have been studied extensively by Hubbard.* Sand samples with median sizes ranging from 0.14 to 0.25 m were found in the immediate region of the inlet (Figure 6). Estimates of gross littoral drift movements[6] at the inlet are about 300,000 cu yd per year, with 100,000 cu yd moving eastward and 200,000 cu yd moving westward.

Historical review

9. The location of Little River Inlet has been relatively stable with respect to its location on the coast. The first survey of the area in 1735 noted that the inlet was just inside the South Carolina State line.[1] Figure 7 indicates that the inlet still maintains close proximity to the State border. The farthest known distance from the State border as shown in Figure 7 was for the 1873 condition when the inlet was almost 1 mile west of the border. Subsequent shoreline configurations indicate an easterly migration of the inlet. Also, Figure 7 shows that after the 1942 period the inlet appears to be widening. This may be in response to the opening of the AIWW in the late 1930's and the addition of fresh water into the estuary through the south AIWW thus increasing the ebb tidal prism and altering the cross-sectional area of the inlet. Figure 8a (1938), one of a sequence of aerial photos of the inlet, shows the inlet at its narrowest width. The AIWW had been completed at this time as noted by the channel and the dredged material deposits in the top of the photograph. Figure 8b (1945) shows a shift of the inlet throat slightly north of the State border. Also, there has been a widening of the inlet on the South Carolina side. The ocean portion of the channel hugs the east shoulder of the inlet indicating a net eastward littoral drift. Mad Inlet, to the east, is also seen, with its channel oriented similar to that of Little River Inlet. Figure 8c

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* Personal communication, D. Hubbard.

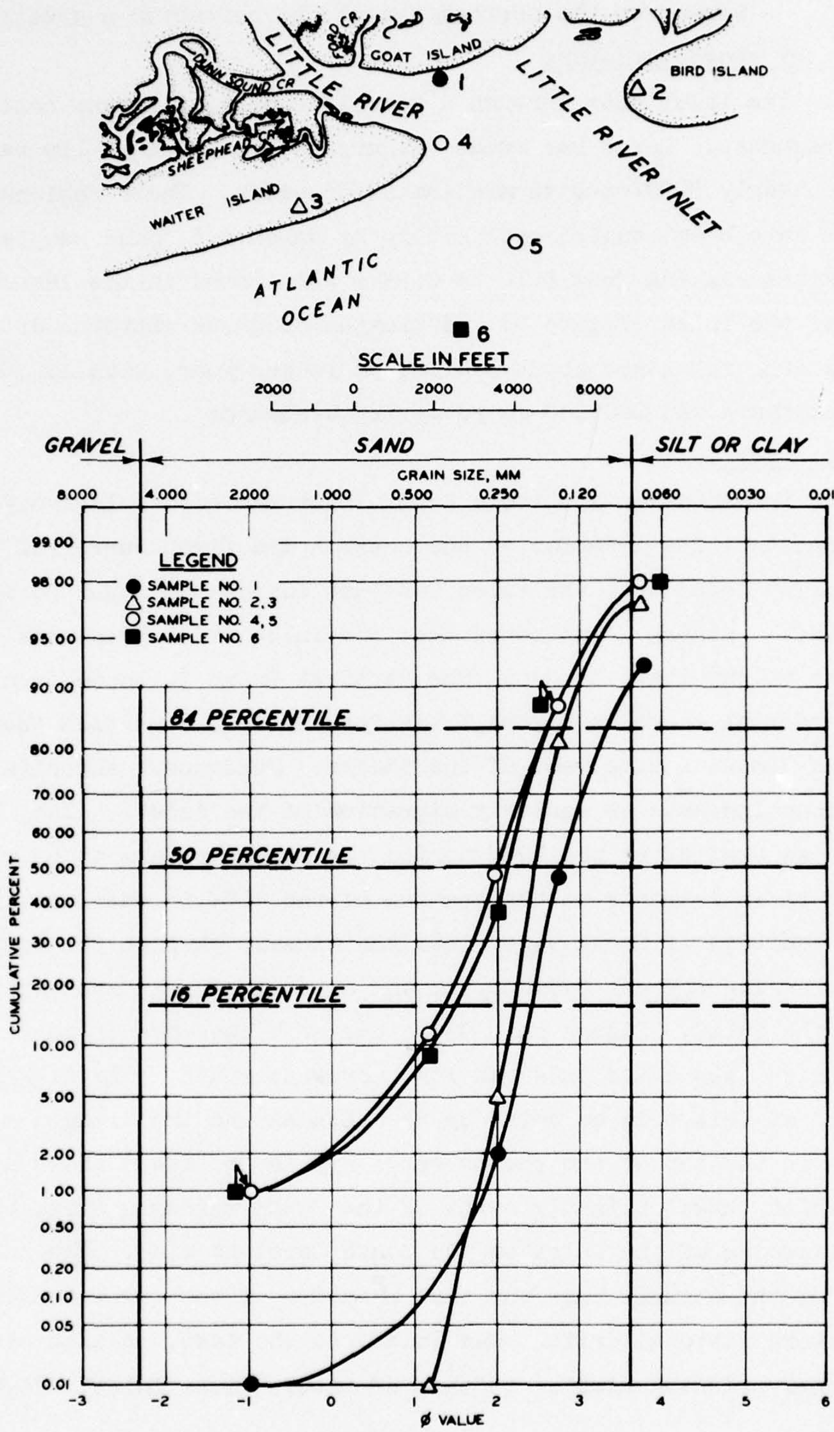



Figure 6. Grain-size distributions

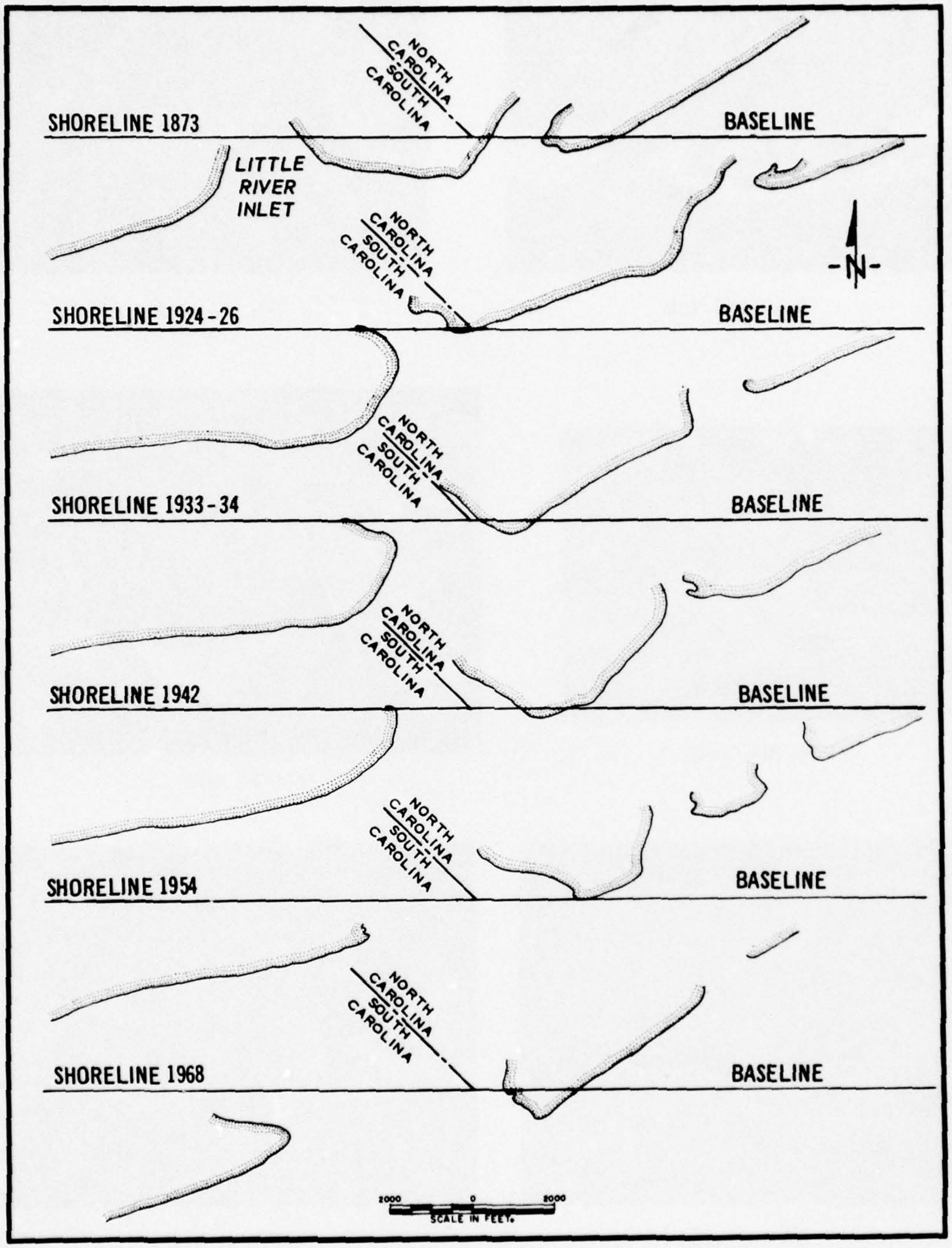
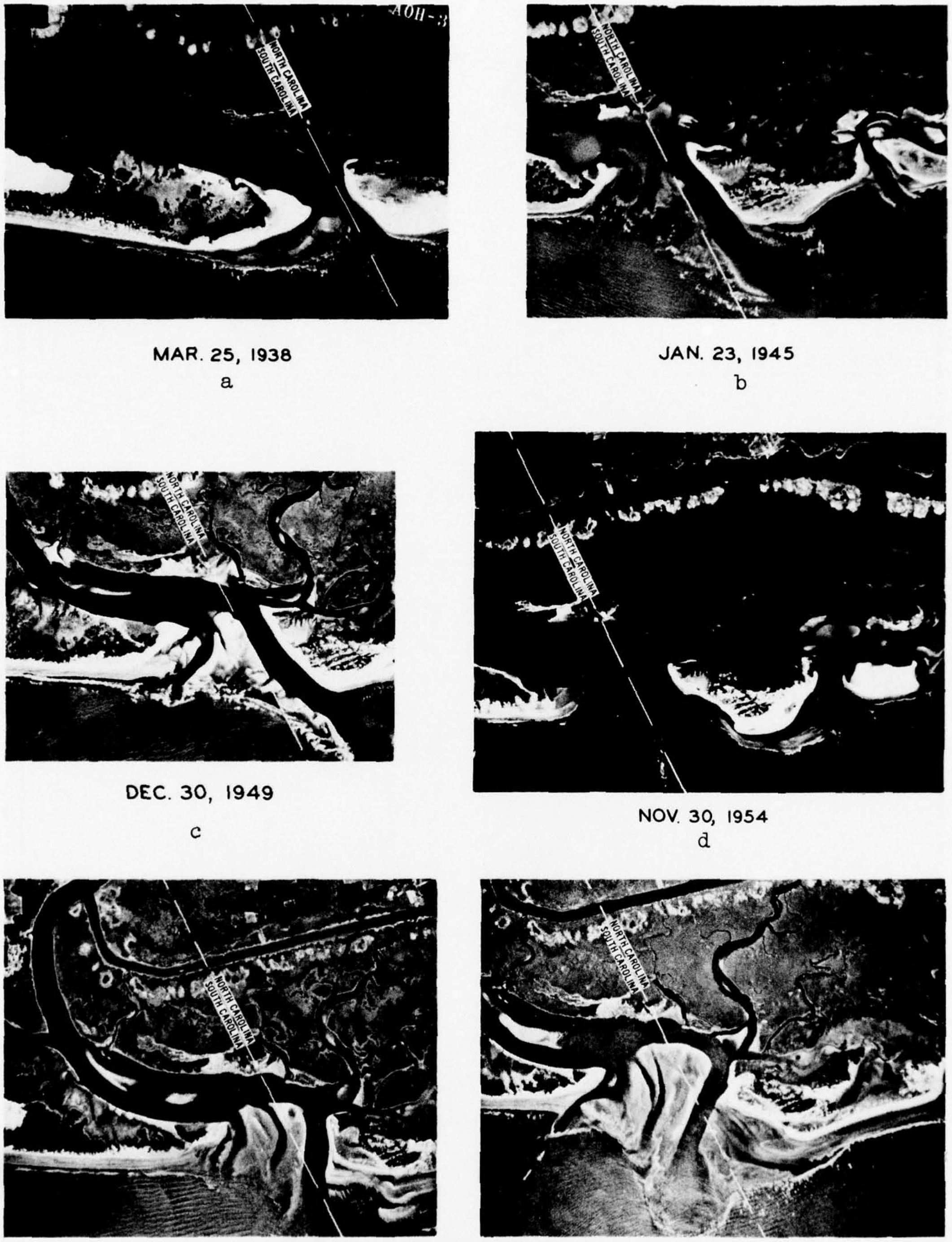



Figure 7. High-water shoreline




MAR. 25, 1938
a

JAN. 23, 1945
b

DEC. 30, 1949
c

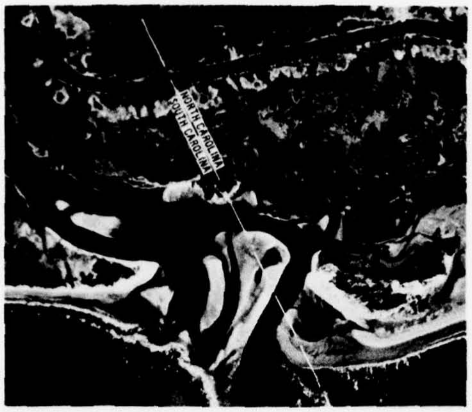
NOV. 30, 1954
d

OCT. 10, 1958
e

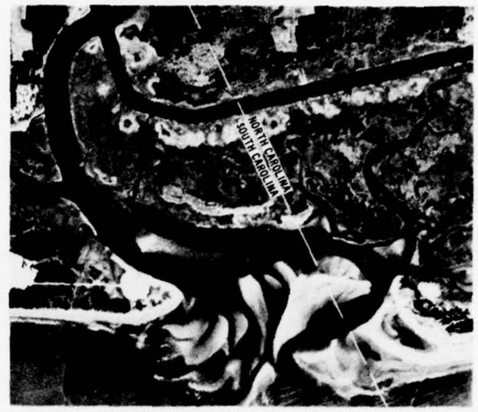
APR. 4, 1962
f

SCALE
2000 0 2000 4000 FT

Figure 8. Little River Inlet, 1938-1974 (sheet 1 of 2)




FEB. 21, 1963
g

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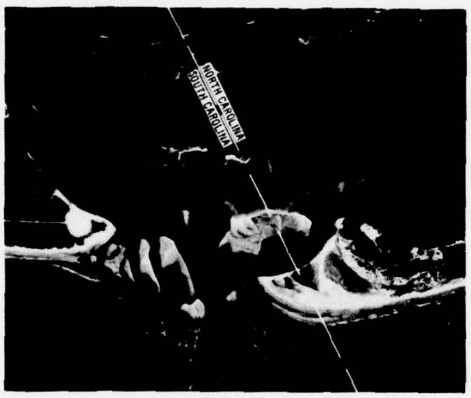



DEC. 4, 1969
i


MAR. 27, 1970
j


DEC. 17, 1972
k


MAR. 19, 1974
l

SCALE

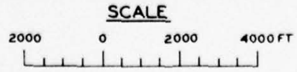



Figure 8 (sheet 2 of 2)

(1949) shows the inlet 4 years later similar in orientation but with more material visible within the entrance region. Figure 8d (1954) shows the inlet region about one month after Hurricane Hazel passed through the area. Considerable erosion occurred, especially near Mad Inlet. Tides 17 ft above mean sea level (msl)[1] cut through the barrier beach in this coastal area during the hurricane. Figure 8e (1958) shows the entrance channel had become oriented perpendicular to the coast. Also, the entrance bar continued to become more extensive, as seen in Figure 8f (1962). Again, there is more influx of material from the east, pushing the entrance channel obliquely to the shoreline in a westerly direction. Figure 8g (1963) is somewhat similar to Figure 8f, about 1 year later. Figure 8h (1968) shows that the filling from the east has made the dominant ebb channel so long that ebb flow has carved channels through the bayside shoal in order to follow a more efficient path to the ocean. Figure 8i (1969) shows greater erosion through the bayside shoal with the remnant of the shoal left inside the inlet. Figure 8j (1970) shows possibly a larger amount of material filling on the various shoals. Figure 8k (1972) indicates more fill on the east shoulder of the inlet. Figure 8l (1974) shows minor changes from the previous photograph along the east and west sides of the inlet. The above sequence of photographs indicates a relatively stable location for the inlet but a very dynamic region in terms of shifting shoals and channels.

## Purpose and Scope of Model Study

10. The Charleston District submitted recommendations to the U. S. Army Engineer Division, South Atlantic, for construction of two jetties and appropriate channels at Little River Inlet, including a 12-ft-deep (mlw) by 300-ft-wide entrance channel and a 90- by 10-ft interior channel. The preconstruction planning and design of the structures require hydraulic model testing to aid in evaluating the effectiveness of the design and to determine if any detrimental effects might occur.

11. Important design parameters and other considerations that needed to be investigated in the model study included:

- a. Optimum alignment of the jetties and the spacing between them.
- b. Minimum length of jetties required.
- c. Proper channel alignment.
- d. Characteristics of the channel with respect to the influx of sediment at the entrance.
- e. Current patterns at the entrance.
- f. Effectiveness of the weirs on the jetties to pass longshore drift into the sedimentation basins.
- g. Evaluation of location of sediment basins.
- h. Effects on tidal prism and bay tides.
- i. Effects on bay salinities.
- j. Qualitative indication of wave heights in the entrance channel and deposition basin.

The above considerations were investigated with a fixed-bed model molded to the prototype bathymetry. The model had the capability to define hydraulic effects by measurement of velocities, tidal elevations, and surface current pattern photographs. Dye was used to trace movements of particular water masses. The study also included sediment tracer tests which were conducted using a lightweight plastic to simulate sand movement and which gave qualitative indications of the effects of various plans on sedimentation. Salinity effects were studied with the introduction of salt water into the model.

## PART II: THE MODEL

### Description

12. The Little River Inlet model reproduced approximately 58 square miles of the prototype including the bay area to the limit of tidal influence southwest in the AIWW and to the intersection of the Little River Inlet-Mad Inlet bay region and the Tubbs Inlet bay area (Figure 9). A layout of the model in Figure 10 indicates that the

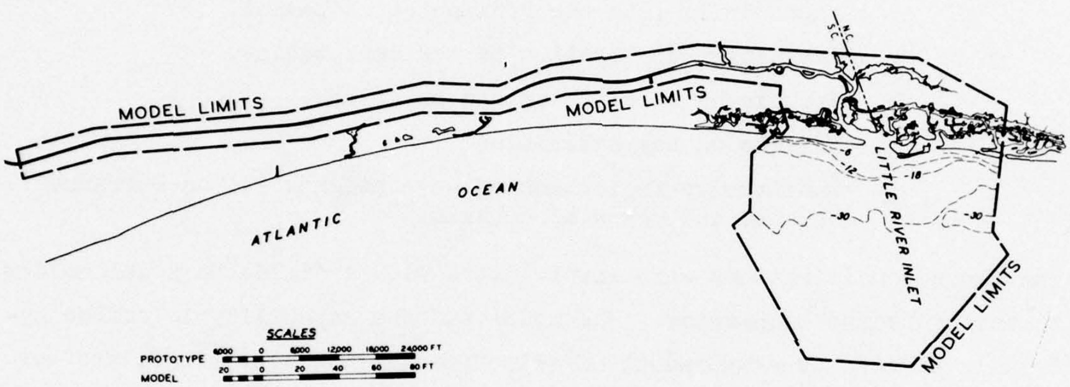



Figure 9. Model limits in prototype

southwest portion of the AIWW has been modeled in labyrinth form in order to more economically model this region. The ocean portion has been accurately molded to the -40 ft contour.

13. The model was constructed to linear scale ratios, model to prototype, of 1:300 horizontally and 1:60 vertically. From these scales, the following relations were computed based on the Froudian law of similitude.

| Characteristic | Scale Relations |
|---|---|
| Horizontal length | $L_H = 1:300$ |
| Vertical length | $L_V = 1:60$ |
| Volume | $L_H L_H L_V = 1:5,400,000$ |
| Velocity | $L_V^{1/2} = 1:7.746$ |

(Continued)

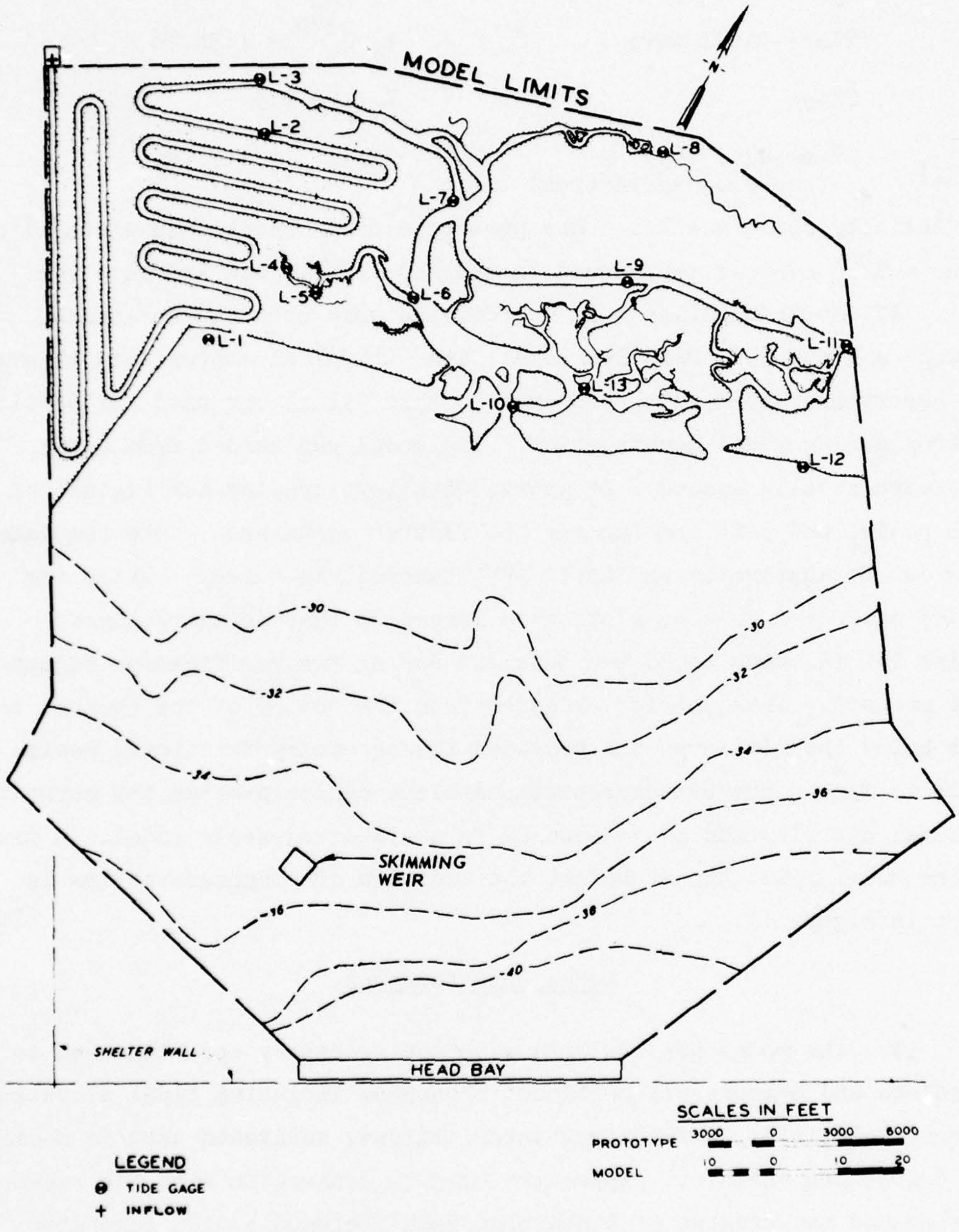



Figure 10. Model layout

| Characteristic | Scale Relations |
|---|---|
| Discharge | $L_V^{3/2} L_H = 1:139,320$ |
| Time--tidal wave | $L_H / L_V^{1/2} = 1:38.76$ |
| Slope | $L_V L_H = 1:5$ |
| Time--wind wave (modeling refraction) | $L_V / L_V^{1/2} = 1:7.746$ |

The salinity scale was 1:1. One prototype tidal cycle (semidiurnal) of 12 hr and 25 min was reproduced in the model in 19 min and 14.4 sec.

14. South Carolina grid coordinates were used for horizontal control and the 1929 Mean Sea Level Datum (tidal elevation data throughout report are given with reference to this datum) was used for vertical control during model construction. The model was molded from metal templates usually spaced 2 ft apart, with 1-ft spacing for regions of high relief and 3-ft spacing for the flatter ocean area. The templates were cut to conform to the April 1974 bathymetric survey. While the molded concrete was wet, slots were formed so that metal roughness strips 1/2 in. wide could be installed during the verification adjustment process. These strips extended from the bottom of the channel to just below the mlw level and provided the necessary frictional resistance to flow since bottom resistance alone cannot provide the correct vertical distribution of resistance in a distorted-scale model. A view of the model inlet throat before the addition of roughness strips is shown in Figure 11.

## Model Appurtenances

15. The model was equipped with the necessary appurtenances to reproduce and measure all pertinent phenomena including tidal elevations, current velocities, waves, freshwater inflows, sediments used in shoaling tests, and salinity. Apparatus used in connection with the reproduction and measurement of these phenomena included a tide generator and recorder, velocity meters, wave generators, an automated flowmeter, tidal gages, sediment recovery apparatus, salinity meter, and chemical titration equipment.

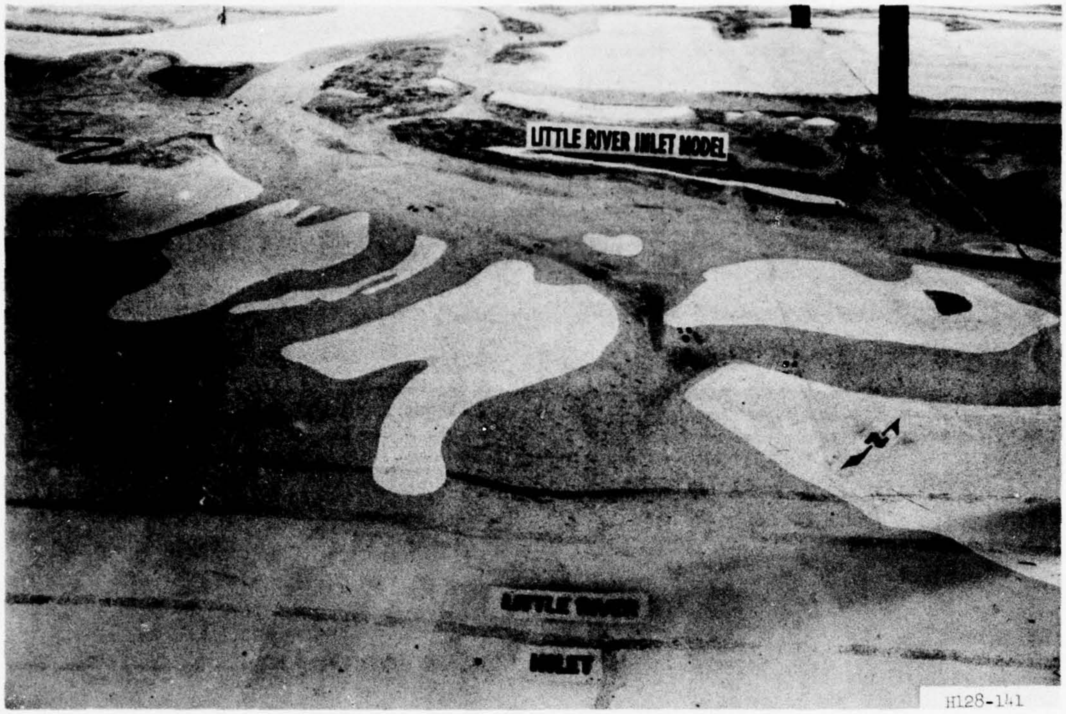



Figure 11. Looking bayward in the model

Tide generator

16. Tides were reproduced in the model by a WES-designed (U. S. Army Engineer Waterways Experiment Station) automatic tide-generator system illustrated in Figure 12. The prototype program cam used in this model as the primary input to the control system was made of a laminated-plastic-cotton-cloth board. Two adjustable steel cams were used to modify any portion of the tide for which a change was desired. The operation of the system as described below is in reference to Figure 12:

a. The water surface in the model (A) is higher than in the sump (B). A pump (C) discharges a constant flow of water against the automatic rolling-gate valve (D). Flow to and from the model is controlled by the automatic rolling-gate valve. If the valve is opened so that the discharge from the pump is retained in the sump a syphoning effect is created and the water-surface elevation in the model is lowered. If the valve is closed the syphoning effect is overcome by the pump, and the water surface in the model rises.

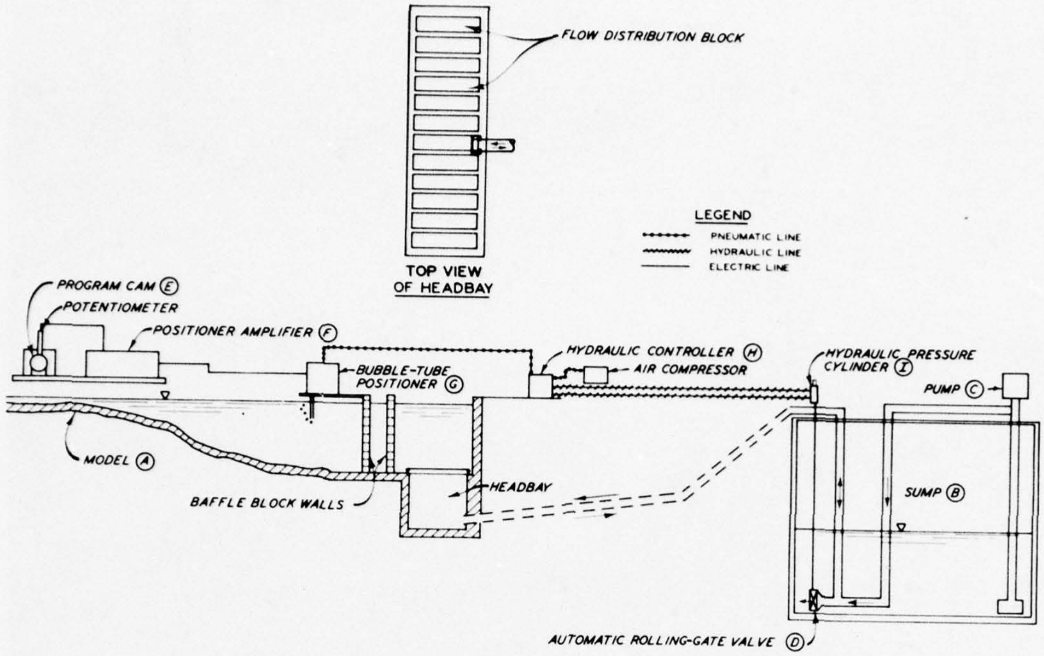



Figure 12. Tide-generator system

b. The desired tide is programmed by a radially eccentric cam (E). The mechanical signal generated by the rotated cam is converted to an electrical signal by the positioner amplifier (F) and transmitted to the bubble-tube positioner (G). The bubble-tube positioner moves an air bubbler tube in the same direction that the water surface should go to produce the desired tide. The air pressure sensed by the bubble tube serves as input to one side of a hydraulic controller (H). The pressure difference (error in water-surface elevation) between the bubble-tube pressure and a preset controller pressure is amplified by the controller and is used to move the automatic gate valve (D) as necessary to obtain the correct water-surface elevation.

c. The following describes the sequence of operations that would occur in the simple case of the tide controller raising the water-surface elevation from a steady-state condition:

(1) The program cam (E) indicates that the water surface is to rise 1 in. A potentiometer converts this mechanical signal to a voltage and transmits it to the positioner amplifier (F).

(2) The positioner amplifier amplifies the signal and

transmits it to the bubble-tube positioner (G), which rises 1 in.

(3) The air pressure in the bubble tube is reduced by its decreased submergence.

(4) The differential between the bubble-tube pressure and a preset pressure is converted to hydraulic pressure and amplified by the hydraulic controller (H).

(5) The amplified hydraulic pressure differential activates a hydraulic pressure cylinder (I) atop the automatic rolling-gate valve (D), causing it to close slightly.

(6) The system continues to respond to the changing water-surface elevation until the desired 1 in. rise is accomplished.

Current velocity meters

17. Current velocity measurements were made in the model with miniature Price-type current meters (Figure 13). Each meter cup was about 0.04 ft in diameter, representing 2.4 ft vertically in the

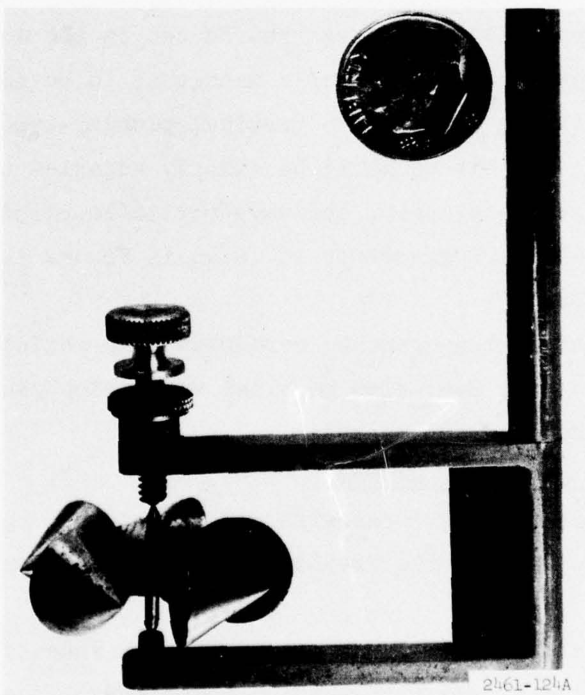



Figure 13. Miniature current velocity meter

prototype. The center of the cup was about 0.045 ft from the bottom of the frame, representing 2.7 ft in the prototype. In a vertical plane the entire meter occupied a space of about 2 by 30 ft when scaled to the prototype. The meters were calibrated frequently to ensure their accuracy of ±0.02 fps (±0.15 fps prototype) and were capable of measuring velocities as low as 0.05 fps (0.4 fps prototype).

Photographic system

18. In order to take surface current photographs, 8- by 10-in. cameras were placed about 15 ft above the water surface of the model. Their shutters were tripped simultaneously by an electronic timer for a 4-sec exposure. An electronic strobe light was flashed near the end of the exposure so that a bright spot was recorded near the tip of the confetti streak, indicating the direction of movement. Surface velocities can be determined by measuring the length of a streak and comparing it with a scale included on each photograph.

Wave generators

19. Prototype wave action was reproduced in the model with 60-ft-long wave generators located in such a manner as to be normal to the direction of prevailing waves. Two vertical plunger-type wave generators were used, and either could be quickly adjusted to generate the desired wave height, wavelength, and wave period required. A section of the vertical plunger wave generator is shown in Figure 14.

Wave measuring system

20. Wave-height measurements were made with resistance-type wave rods, consisting of two 2-mm-diam parallel wires electrically connected to a light beam oscillograph recorder.

Freshwater inflow measuring device

21. The model was equipped with a constant-head tank and attached rotometer to reproduce precise freshwater inflow as shown in Figure 15.

Tide gages

22. Tidal-stage history was measured by the use of an electronic system consisting of a transmitter (Figure 16) and a recorder (Figure 17) with a telemetering circuit consisting of two selsyn motors, one in the transmitter and the other in the recorder, connected by an

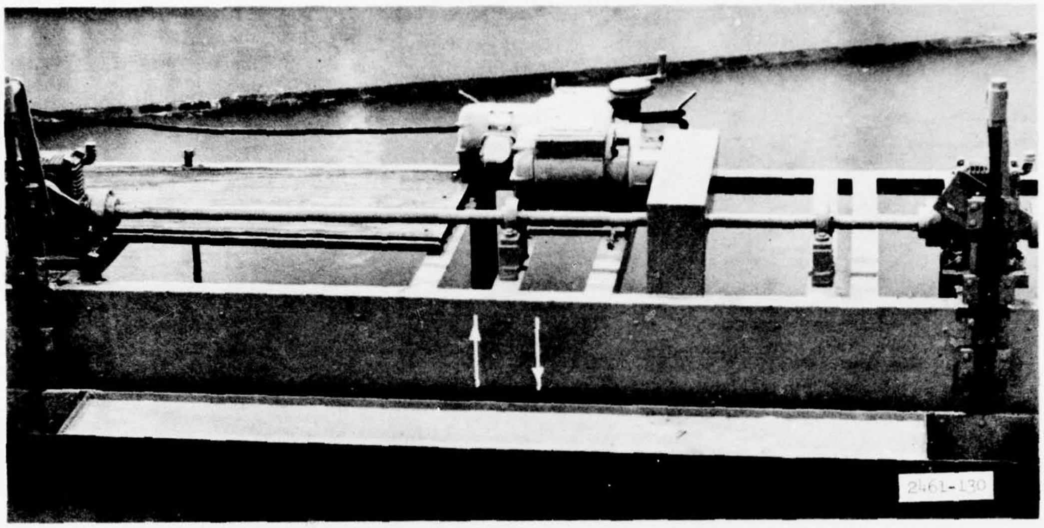



Figure 14. Section of vertical plunger wave generator

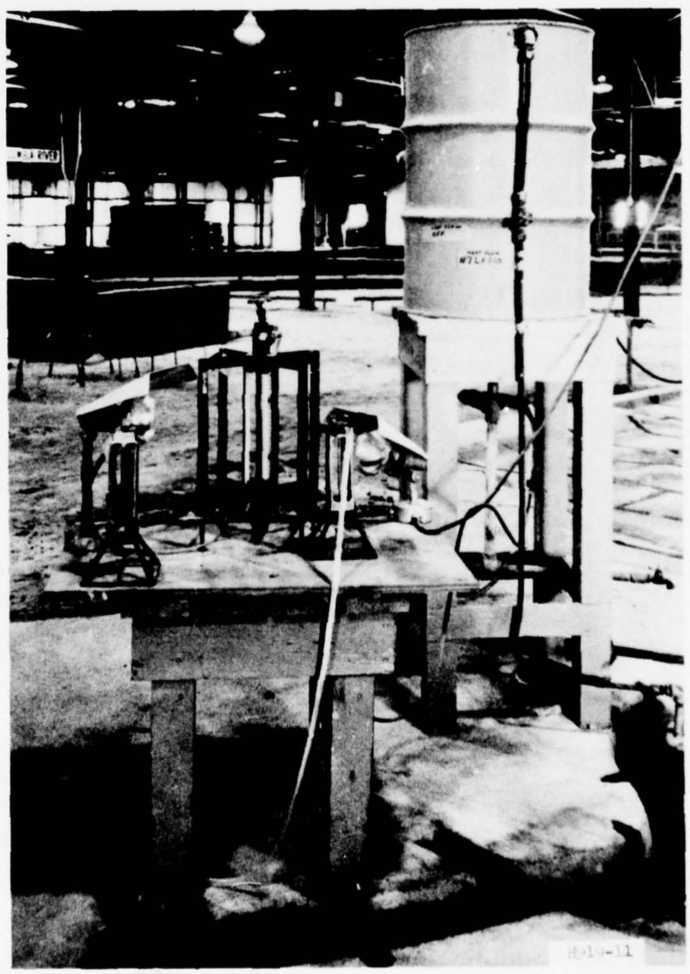


Figure 15. Freshwater inflow system

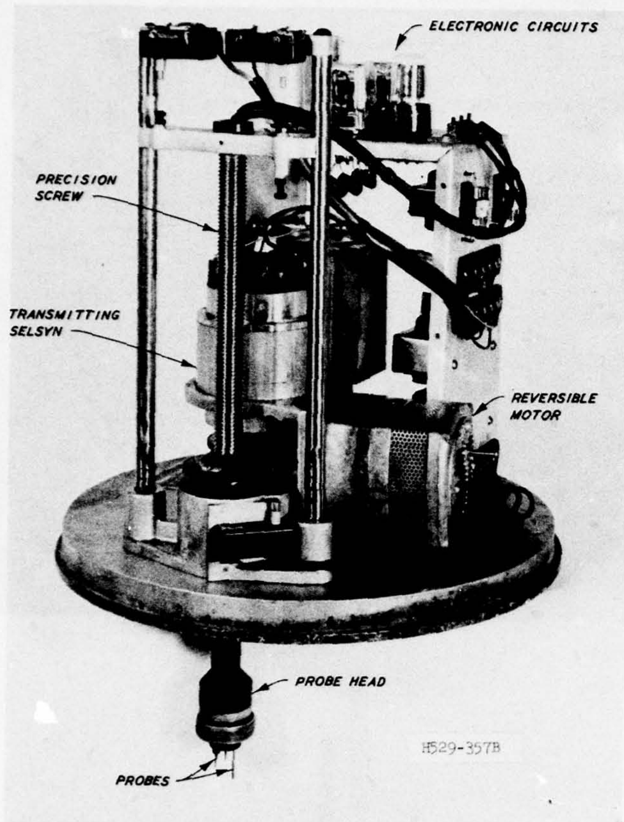



Figure 16. Water height transmitter with cover removed

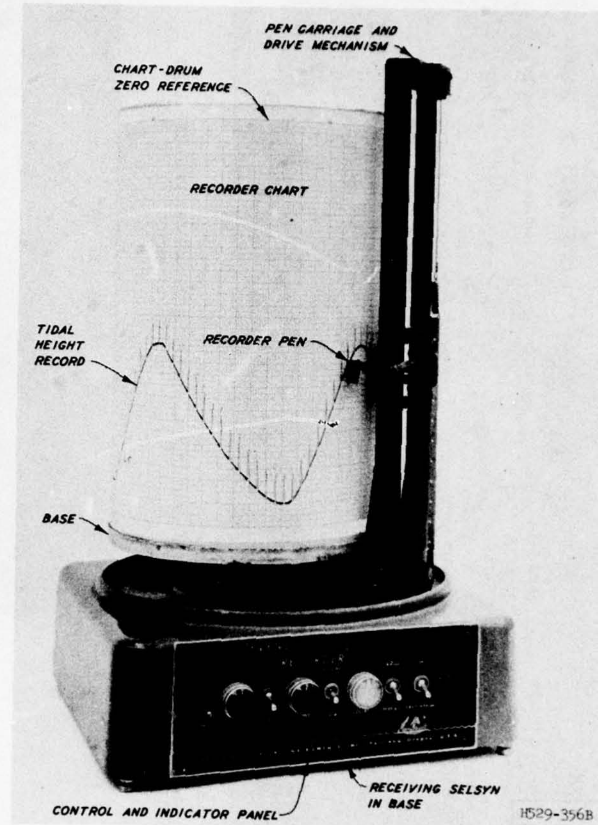



Figure 17. Water height recorder

electrical cable. The tidal stage transmitter, located over the desired data gathering point, measured the water-surface elevation by means of an electronic sensing probe and transmitted this elevation to a recorder located in a control or instrument house. An ink pen continuously recorded the water-surface elevation on a chart that was turned automatically at a preset rate to give a plot of water-surface elevation versus time. Portable point gages were also used to measure tidal elevation at other points as required.

Shoaling injection
and recovery apparatus

23. Shoaling material injection was accomplished in the model by placing the material by hand. After each test the material was picked up with a jet pump wand (Figure 18). The lightweight wand offered a

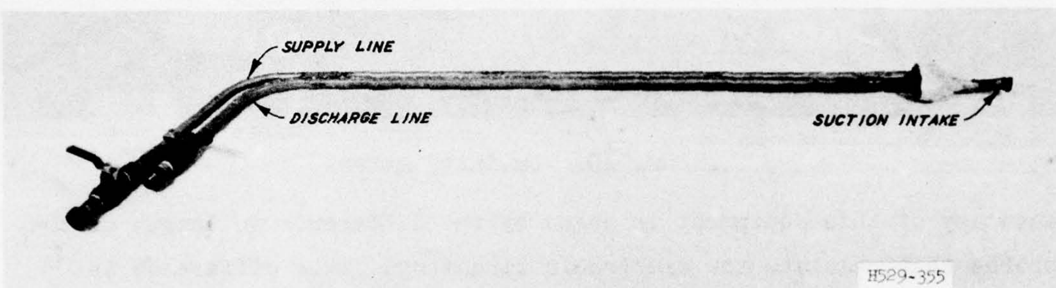



Figure 18. Jet pump wand

high suction-to-supply flow ratio and was supplied from the city waterlines.

Salinity meter

24. Salinity concentrations of samples taken from the model were determined by use of a salinity meter consisting of conductivity cells especially built and calibrated for this purpose (Figure 19). The accuracy of the meter was checked frequently by chemical titration.

## Limitations of the Accuracy of Model Measurements

Tidal elevation

25. Measurements of tidal elevations in the model were made with automatic telemetering transmitters and recorders. The degree of

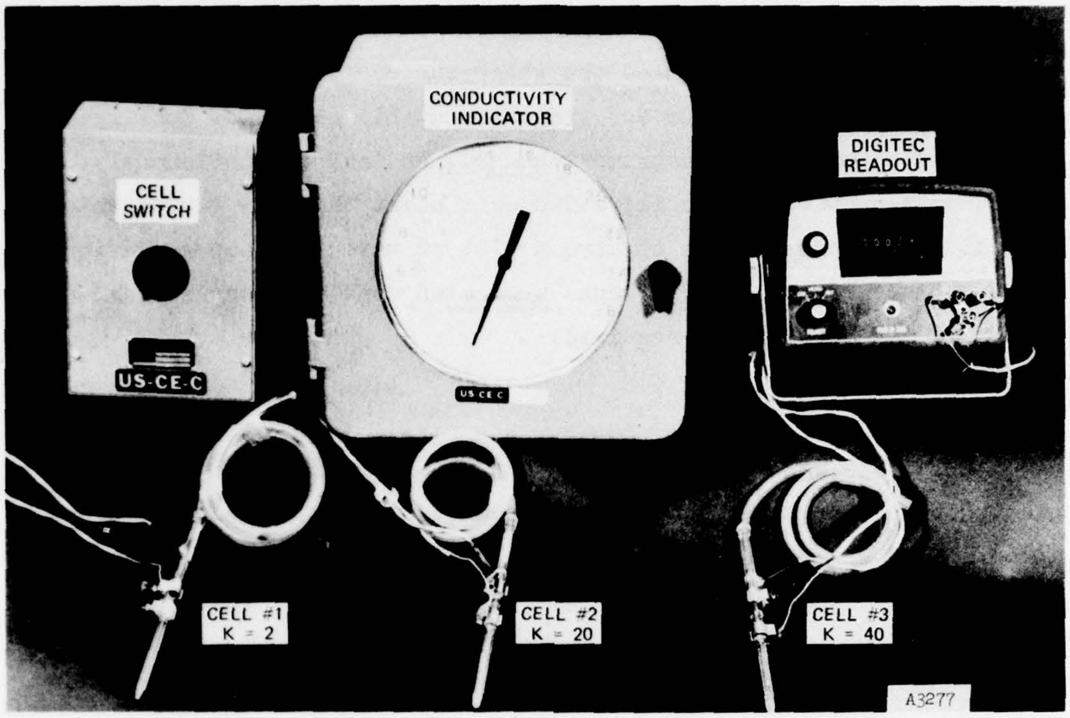



Figure 19. Salinity meter

accuracy of this equipment is gaged by the difference in length of the probes that regulate the electronic circuitry. This difference is 0.004 in., which gives a model accuracy within 0.02 ft in prototype. However, the accuracy with which the chart (Figure 17) can be read is from 0.05 to 0.1 ft prototype. Therefore, tidal elevation could be measured with an accuracy of about 0.1 ft prototype.

Velocities

26. Limitations of the current velocity meters used in the model should be considered in making close comparisons between model and prototype velocity data. The center line of the meter cup was about 0.05 ft above the bottom of the frame; therefore, bottom velocity measurements in the model were actually obtained at a point 3.0 ft (prototype) above the bottom, instead of about 2.0 ft as in the prototype metering program. Model velocities were determined by counting the number of revolutions in a 10-sec interval (which represents a period of about 6.5 min in the prototype) compared with about a 1-min

observation in the prototype. The horizontal spread of the entire meter cup wheel was about 0.11 ft in the model, representing about 33 ft in the prototype, compared with less than 1.0 ft for the prototype meter. Thus, the distortion of area (model to prototype) results in comparison of prototype point velocities with model mean velocities for a much larger area. The same is true for the vertical area, since the height of the meter cup was about 0.04 ft (2.5 ft prototype) compared with only a few inches for the prototype meter. Calibrations and mechanical operation of the velocity meters, capable of measuring velocities to a minimum of 0.05 fps (0.4 fps prototype), were checked frequently during verification to ensure accurate operation. Calibration of the meters is to ±0.01 fps, which is about ±0.07 fps prototype. The meter revolutions were counted to ±1/4 revolution during a 10-sec measurement period. This is equivalent to ±0.02 fps or ±0.15 fps prototype.

Discharges and flow volumes

27. The variance in velocity measurement causes a variance in subsequent discharge and flow volume calculations. For example, for a cross-sectional area of 8000 sq ft and a velocity of 3.00 ±0.15 fps, the discharge would be some value between 22,800 and 25,200 cfs, any error in cross-sectional area notwithstanding. For flow volumes, consider an average ebb velocity of 1.50 ±0.15 fps over a duration of 22,500 sec prototype (1/2 tidal cycle) and a cross-sectional area of 8,000 sq ft; the flow volume would be some value between 243 million and 297 million cu ft.

Wave heights

28. The instrumentation used to measure wave heights can detect changes in water-surface elevation to ±0.001 ft (0.06 ft prototype). For this study, wave data were recorded on a light-beam oscillograph from which direct measurements were made by measurement with a ruler. Due to the width of the light-beam trace, wave heights were read to 0.003 ft (0.18 ft prototype). Repeat tests average about ±10% variation in heights for identical conditions. However, another factor of error is important since the model was distorted so that wave diffraction and refraction similitude cannot be simultaneously achieved.

Refractive effects are depth-dependent; consequently, wavelength is scaled by the vertical scale. Diffractive effects are correctly scaled by the horizontal dimension, and thus, wavelength would also be scaled in this way. In the Little River Inlet, refraction was correctly scaled so scale effects due to diffraction could be expected. No exact analysis of the error is known to exist. However, based on the facts that wavelengths scaled for correct refraction are longer than those scaled for diffraction by a factor of the model distortion and diffraction scaled waves are more frequent by a factor of the square root of the model distortion, energy per unit time is greater in refraction scaling by a factor of $\sqrt{5}$ than when diffraction is scaled. This is assuming that the same prototype wavelength and period are modeled in each case. As a result, model waves satisfying refraction similitude would have $\sqrt{5}$ times greater energy in a diffraction zone; thus, model results would give conservative results when scaled to the prototype.

## PART III: MODEL VERIFICATION

### Introduction

29. Verification (calibration) of a hydraulic model is an important part of a model study. The model must demonstrate an ability to accurately reproduce known prototype phenomena prior to its use as a predictive tool. After a proper verification, the model can be used to predict changes due to proposed plans which are tested under conditions similar to those established during the verification. There were two phases of verification for the Little River Inlet model: first, a hydraulic verification of tidal elevations, velocities, and current directions; second, a salinity verification.

### Prototype Data

30. Prototype velocity and salinity data were collected for one complete tidal cycle on 30 April 1974 by Charleston District and WES personnel. Locations of data collection Ranges 1-7 are shown in Figure 20, with the stations of each range designated by the letters, A, B, or C. At each station, velocity and salinity data were measured at the surface, middepth, and bottom if the location was sufficiently deep; otherwise, surface and bottom or just middepth measurements were made at shallower locations. At some stations, two depths were read at higher tides; but during periods of low water, only one depth could be read. Simultaneously, tidal elevations were measured at locations in the ocean and throughout the bay (Figures 10 and 20) with automatic gages installed by the U. S. Geological Survey (USGS).

31. Data analysis of the prototype velocities and salinities indicated the presence of fresh water in the system. Flow discharge and volume calculations at Range 5 indicated a net oceanward flow of 1200 cfs. However, differences between surface and bottom salinities were slight so effects of vertical density variance on the flow would be insignificant. Therefore, the verification proceeded using only

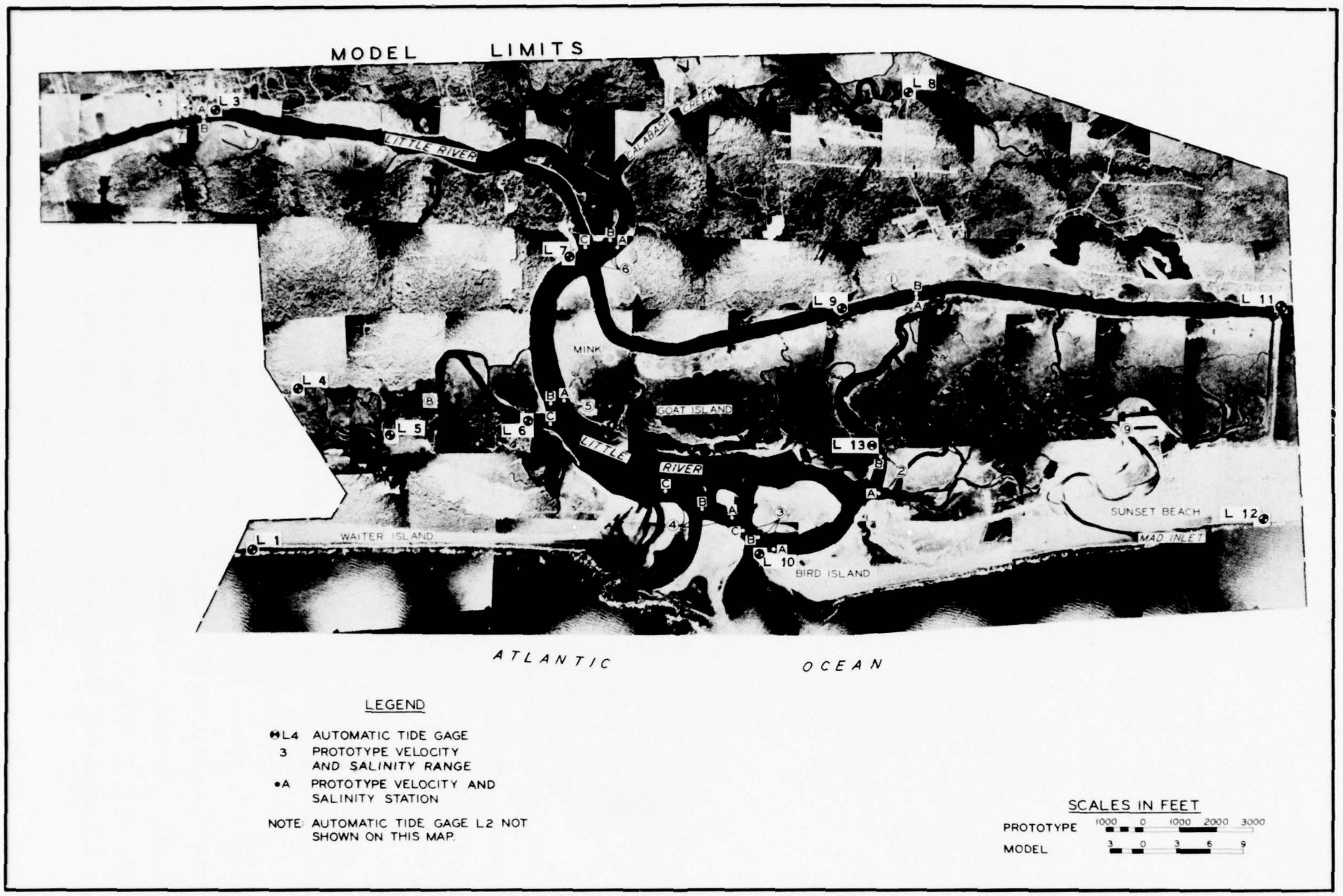



Figure 20. Prototype range and station locations

fresh water in the model ocean and introducing net freshwater inflow into the AIWW at the far end of the labyrinth (Figure 10) to produce the correct mass transport through the bay. Later on in the study it was decided that the effects of the plan on bay salinities should be examined; therefore, the ocean was filled with salt water and fresh water was introduced into the AIWW.

## Hydraulic Verification

32. The initial step of the model verification was the adjustment of the tide control mechanism so that the prototype tide was accurately reproduced in the ocean at the control gage L12 (Figure 20). The 5.0-ft ocean tide varied from a high water elevation of 2.4 ft mean sea level (msl) to -2.6 msl. At the time of this report the msl datum was related to local mean low water (mlw) by a difference of 2.5 ft, i.e., msl = +2.5 ft mlw, or conversely mlw = -2.5 ft msl. Once the prototype tide was reproduced in the ocean, model roughness (metal strips) was inserted into the preformed slots in the channel bed and varied in quantity and location until the proper elevation and phase relations were reproduced with respect to the prototype tide curves. Once model-prototype tide elevations were in relatively good agreement, velocities were checked and additional refinements in roughness were made. Another adjustment found necessary for proper calibration was the timing of the freshwater inflow into the AIWW. An electric valve was put on the freshwater inflow waterline at the western end of the AIWW, and various timing sequences were tried until an appropriate one was found. Also, at the eastern end of the AIWW, an electric valve was placed at the intersection of the AIWW with the model wall in order to achieve velocity verification at Range 1 (Figure 20). The prototype data showed that the net flow at Range 1 was heavily weighted in the eastward direction with very little return flow on the westward direction. Therefore, the valve was adjusted to open such that a net eastward flow was produced.

33. Not all gages shown in Figures 10 and 20 were verified due to the absence of prototype tide elevation data on the day of the velocity

survey. Tidal elevation gages 3, 4, and 8 were excluded from verification. However, model data were collected at these locations and were a part of the base data to be compared with the plan data. The prefix "L" on tide gage numbers in Figures 10 and 20 was dropped on the data plates. Figure 21 shows an example of the tidal elevation verification data at sta 6, 7, and 9 which is a good representation of conditions within the bay. Most differences are within 0.1 ft, with the maximum difference between model and prototype being 0.3 ft. Tide phases were in close agreement with the prototype data. All the tidal elevation verification results are presented in Plates 1-4.

34. Velocity verification was successfully completed following the tidal elevation verification. Figure 22 shows velocities at sta 3C located near the inlet throat where the greatest portion of inflow and outflow occurs. These curves comparing model and prototype indicate a good reproduction of velocities in the model. Plates 5-22 contain the velocity verification data for Ranges 1-7.

## Salinity Verification

35. During the prototype survey of 30 April 1974, salinity samples were collected hourly throughout the tidal cycle at Ranges 1-7 (Figure 20). These samples were then analyzed in the field the next day on a conductivity indicator and the salinities were recorded. Following the survey, an examination of the salinities indicated a source of freshwater inflow from the south through the AIWW. The AIWW south of the town of Little River is a man-made land cut extending almost 26 miles to its connection with the Waccamaw River (Figure 1). Evidently a portion of the flow from the Waccamaw River is diverted down the AIWW toward Little River Inlet. The proportion of Waccamaw River water that flows into Winyah Bay is not known and probably varies with the stage of tides in the two estuaries and the amount of fresh water entering the system.

36. It is believed that a reasonable correlation of freshwater flow entering the Little River Inlet region with that measured on the Waccamaw River near Longs, S. C. (Figure 1), was determined by an

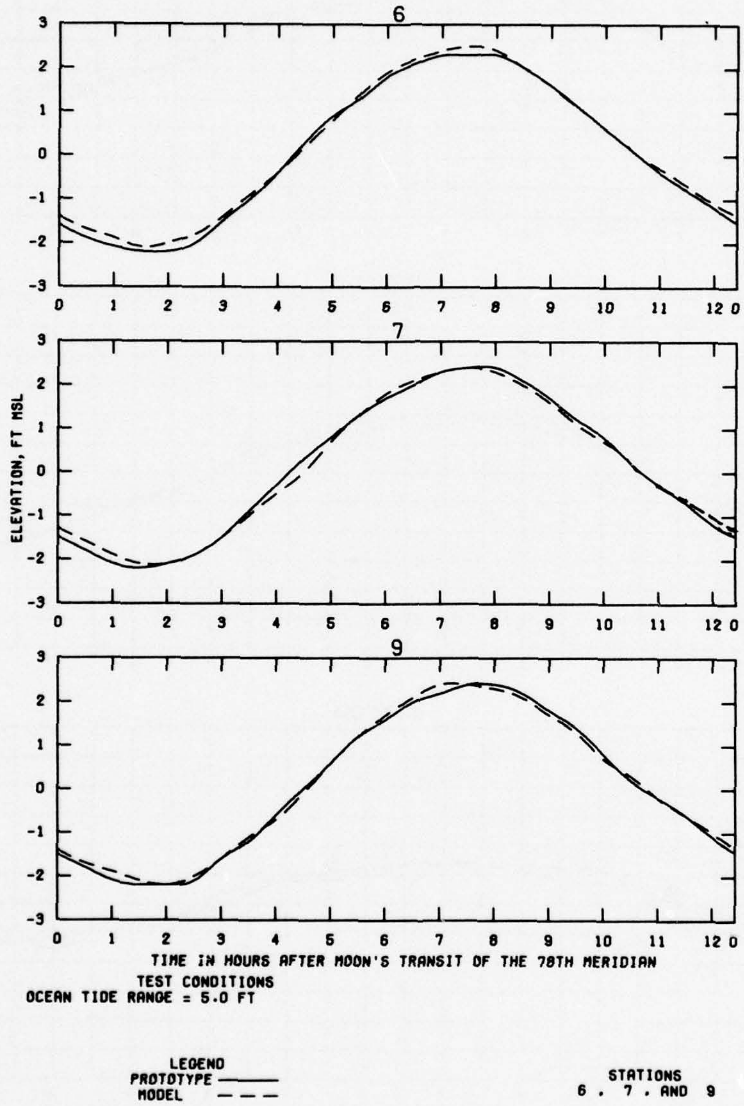



Figure 21. Verification of tidal heights

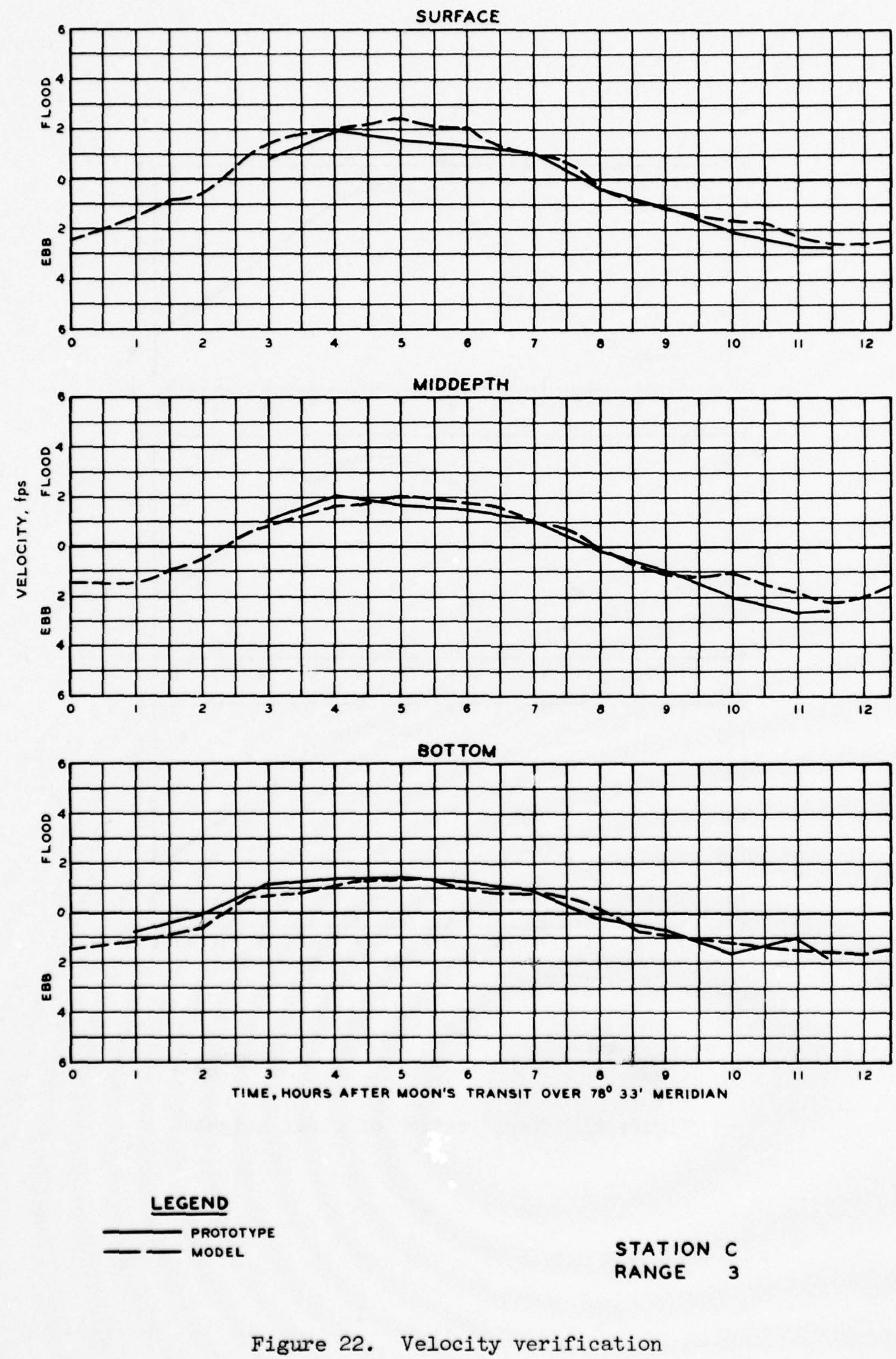



Figure 22. Velocity verification

examination of the integral of the discharges through Range 5. The 30 April 1974 prototype data showed a net oceanward ebb flow of 57.8 million cu ft at Range 5. When averaged over the tidal cycle this results in an average oceanward flow of 1292 cfs. According to USGS Water Supply Papers, the discharge on the Waccamaw River on 30 April 1974 was 1310 cfs; this is almost identical with the net oceanward flow at Range 5. Also, the USGS made discharge measurements near the location of Range 5 on 21 August 1969; the average oceanward flow on that day was 4473 cfs. The USGS Water Supply Papers indicate that the discharge near Longs, S. C., was 4800 cfs on the same day. Based on these data, a direct relation between the discharges near Longs, S. C., on the Waccamaw River and the net oceanward flow at Range 5 was assumed. This analysis showed that the portion of flow in the Waccamaw River which is contributed by the watershed above Longs eventually flows through Little River Inlet and appears to be of the same magnitude. Therefore, an examination of the 1974 hydrograph near Longs (Figure 23), produced an estimate of the variation of freshwater inflow into Little River Inlet. Flows varied from 30 to 5600 cfs. The average discharge near Longs was 1205 cfs. This compares closely with the flow on the day of the prototype survey and suggests that the survey was made on a day of average freshwater inflow.

37. Salinity is defined as the total amount of solid material in grams contained in one kilogram of seawater under the condition that all carbonate has been converted to oxide, bromide and iodine are replaced by chlorine, and all organic matter is completely oxidized. The ocean salinity was reproduced to a 1:1 scale ratio in the model with sodium chloride.

38. Certain operational procedures were set up and followed for each test run. First, a barrier separating fresh water and salt water was placed between Ranges 6C and 7. This barrier was removed at the start of a test to facilitate faster stabilization of the model. The model was then operated for 5 to 6 hr before data were taken to allow sufficient time for stabilization. The average difference between data points of identical runs was 0.7 ppt. Salinity samples were collected

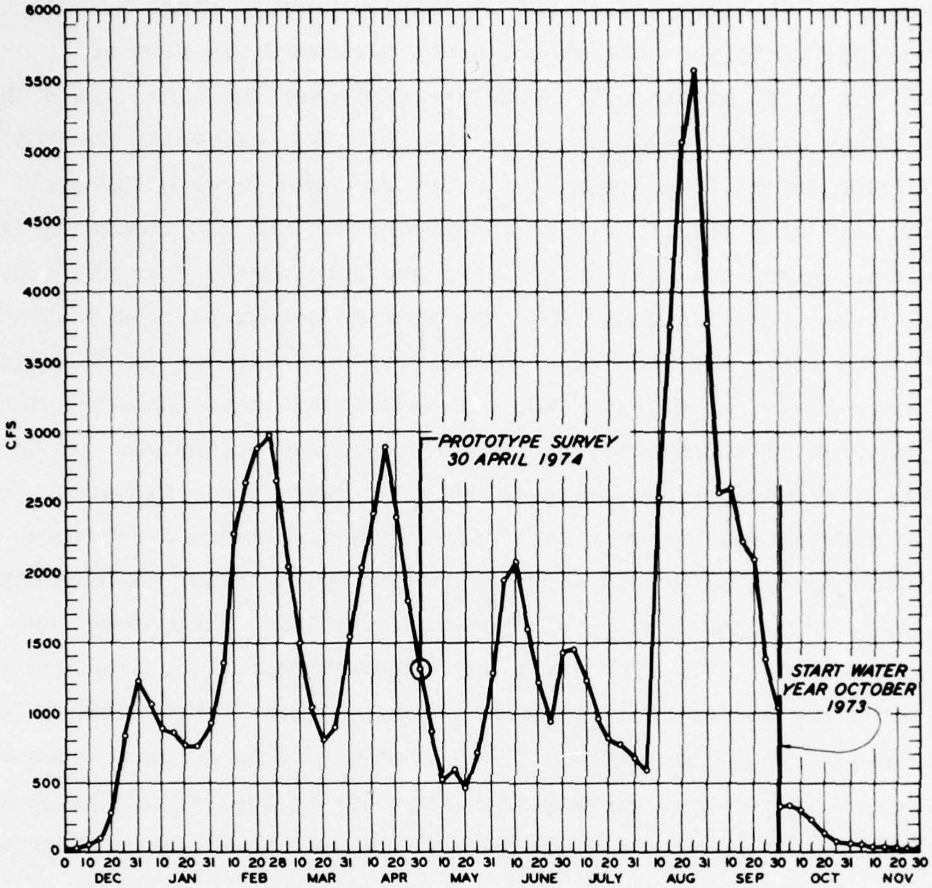



Figure 23. 1974 hydrograph near Longs, S. C., for Waccamaw River

with pipettes and the samples were analyzed on the same conductivity meter that was used for the prototype samples. This meter has an accuracy of ±1 percent of the reading. It was necessary to make minor changes in the roughness strips and the timing of the freshwater inflow to achieve a satisfactory salinity verification. These changes did not cause any significant variation in tidal elevations; thus, it could be assumed that velocities were not significantly varied either. After a number of test runs, the verification data compared favorably with the prototype salinities. Table 1 shows the average salinity for the tidal cycle at each station for both model and prototype conditions. The average difference between model and prototype values was 2.3 ppt. The

average difference at the bottom (3.1 ppt) was somewhat higher than that at the surface (1.7 ppt). An example of the verification is shown in Figure 24 at Range 5. The model-prototype comparison of all salinity data appears in Plates 23-38.

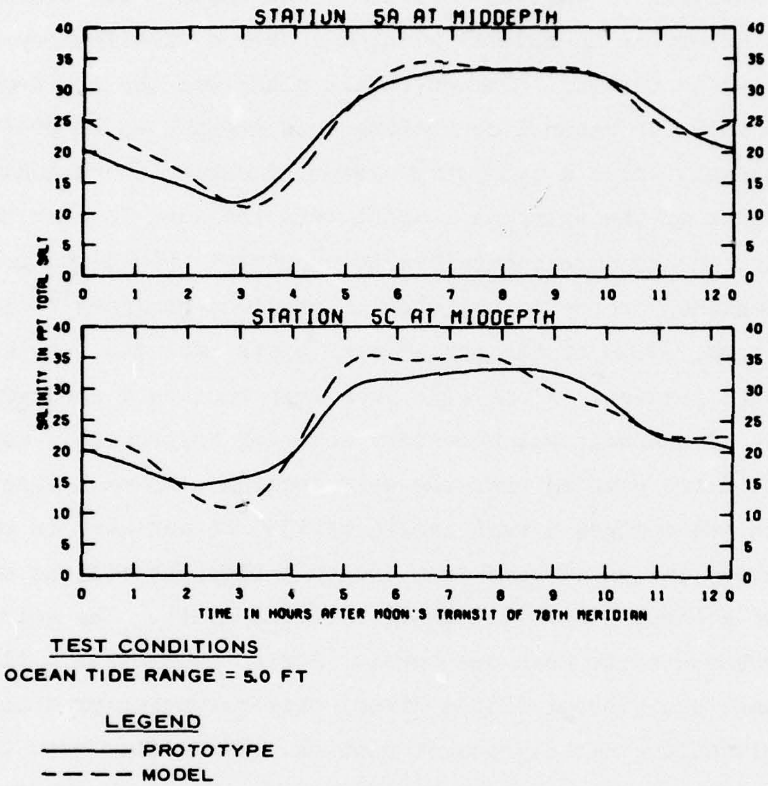



Figure 24. Verification of salinities

## PART IV: TESTS AND RESULTS

39. Once the model was verified it was ready to be used as a tool for predicting changes to the existing hydraulic and salinity conditions due to the addition of various structures and channel and basin dredging. In order to determine an optimal plan, a number of preliminary plans were subjected to testing. Common to all plans was the 12-ft-deep by 300-ft-wide entrance channel connecting to a 10-ft-deep by 90-ft-wide interior channel. Also a two-jetty system, flanking the upcoast and downcoast sides of the entrance channel, was included in each case. A single jetty, though more economical to construct, would not provide sufficient channel protection as seen in previous analyses[7,8] of single jettied systems. Some of the preliminary tests included weir sections on one or both jetties. Along with each weir section a dredged basin on the bay side of the weir was necessary in order to provide a receptacle for littoral drift passing over the weir section. In each case where a weir section was tested, a weir length of 1300 ft was used in order to prevent a heavy influx of sand from suddenly blocking off the weir in the event of a large storm with heavy littoral drift. The weir elevation was constructed to mean sea level. For an inlet with a tidal prism and tide range the size of Little River, this elevation produces a desirable tide elevation-velocity phase relation. Flood flow over the weir brings the sediment into the deposition basin. The peak ebb currents, however, occur after the water level is beneath the weir elevation, permitting currents to concentrate their power in the channel region between the jetties (Figure 25).

40. During the preliminary design process, the question of the appropriate jetty spacing (i.e., the width between parallel jetties or if not parallel jetties, then the minimum distance between the jetties) for a given size of tidal prism must be taken into consideration. O'Brien's formula[9] $A = 4.69 \times 10^{-4} P^{0.85}$ relating spring tidal prism, P (cu ft) to minimum cross-sectional area, A (sq ft), for jettied inlets can be adapted to produce the graphs in Figure 26A--lines of average depth expected for given jetty spacings and tidal prisms. The

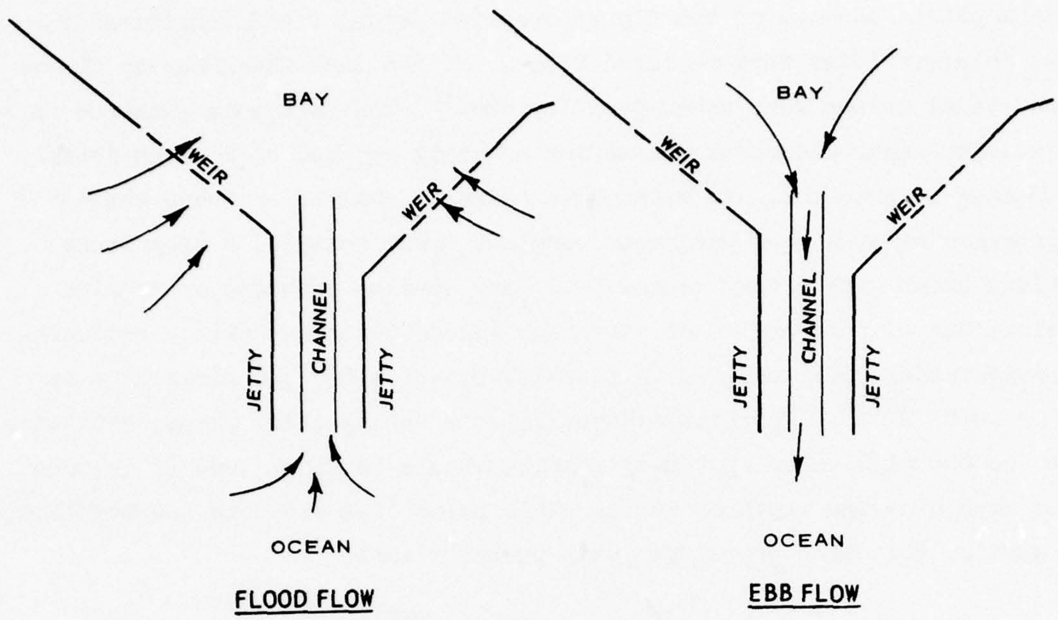



Figure 25. Weir jetty flow patterns

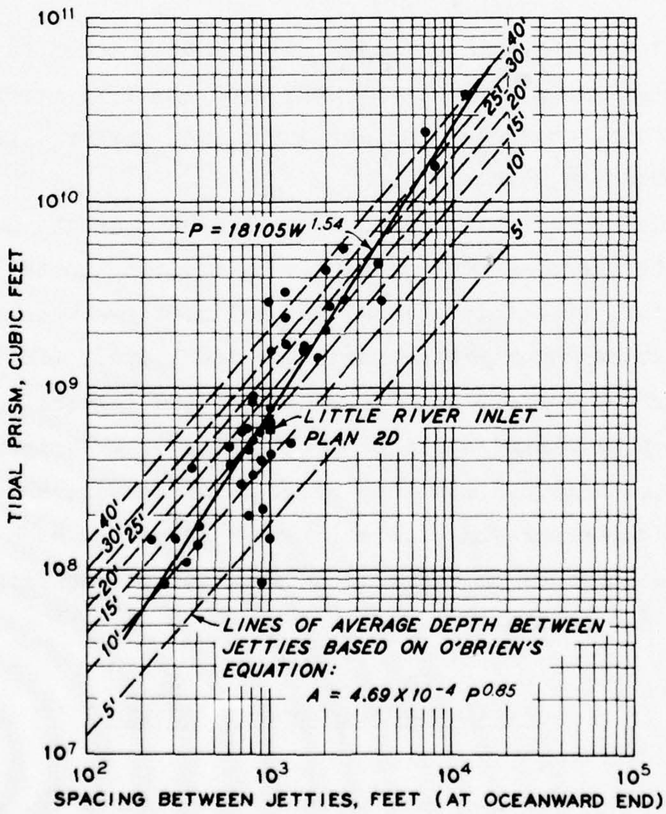



Figure 26. Tidal prism (P) versus jetty spacing (W)

data points plotted on the figure describe actual field conditions for 44 inlets. Widths were measured from U. S. National Ocean Survey Charts and tidal prisms were taken from Jarrett.[10] The data were gathered to see what magnitude tidal prisms are actually handled by a given jetty spacing in practice. No attempt was made to analyze or judge whether problems existed at a particular project. For example, a very large tidal prism with a very narrow jetty may develop problems of erosion along one of the jetties or very high velocities might exist, producing navigational difficulties. A best-fit equation for the field data is $P = 18105\ W^{1.54}$. For Little River Inlet's spring tidal prism, estimated to be 600 million cu ft, jetty spacing should be about 1000 ft in order to have a design depth of 12 ft. This point lies close to the best-fit equation for other prototype jetty installations.

## Test Conditions and Base Data

41. All testing was performed using a mean ocean tide range of 5.0 ft. Freshwater inflow into the bay from the AIWW averaged 1200 cfs for a tidal cycle, which is considered the mean inflow. The bathymetry was that recorded in March 1974.

42. Model verification data were also used as the base test for comparison with the plan test results. In addition to the measured base data--velocities, tidal elevations, and salinities--surface current photographs were taken hourly throughout the tidal cycle (Photos 1-13). These base surface current photographs were used initially for comparison with the preliminary surface current data of a variety of plans. In some cases, additional stations for velocities were added for which there were no comparable base data. This occurred in such locations as in a dredged channel or near the jetty structure, conditions which did not exist for the base data.

## Preliminary Hydraulic Testing

43. The three basic plans are shown in Figures 27, 28, and 29.

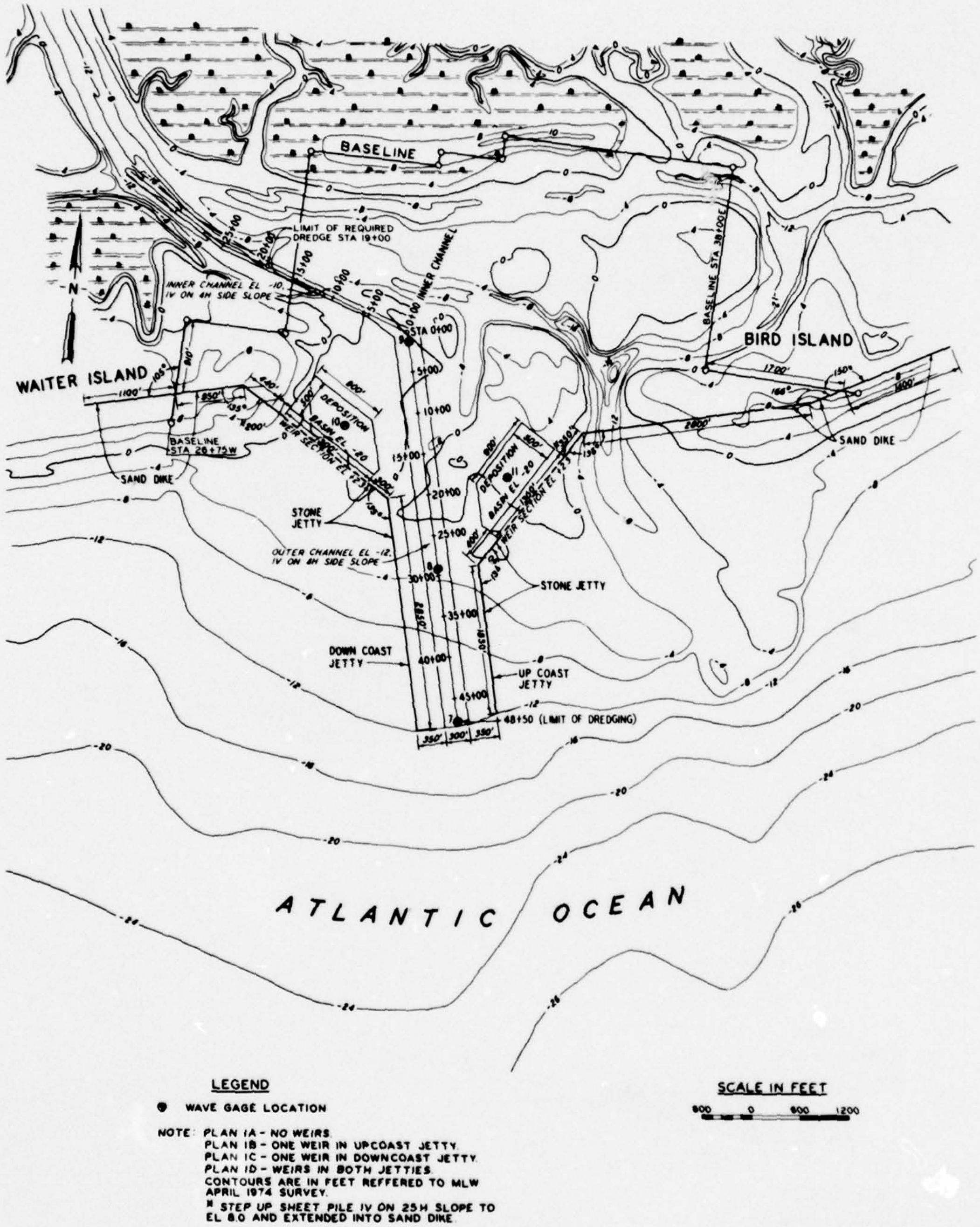



Figure 27. Jetty and channel alignment for Plans 1A, 1B, 1C, and 1D


Figure 28. Jetty and channel alignment for Plans 2A, 2B, 2C, and 2D

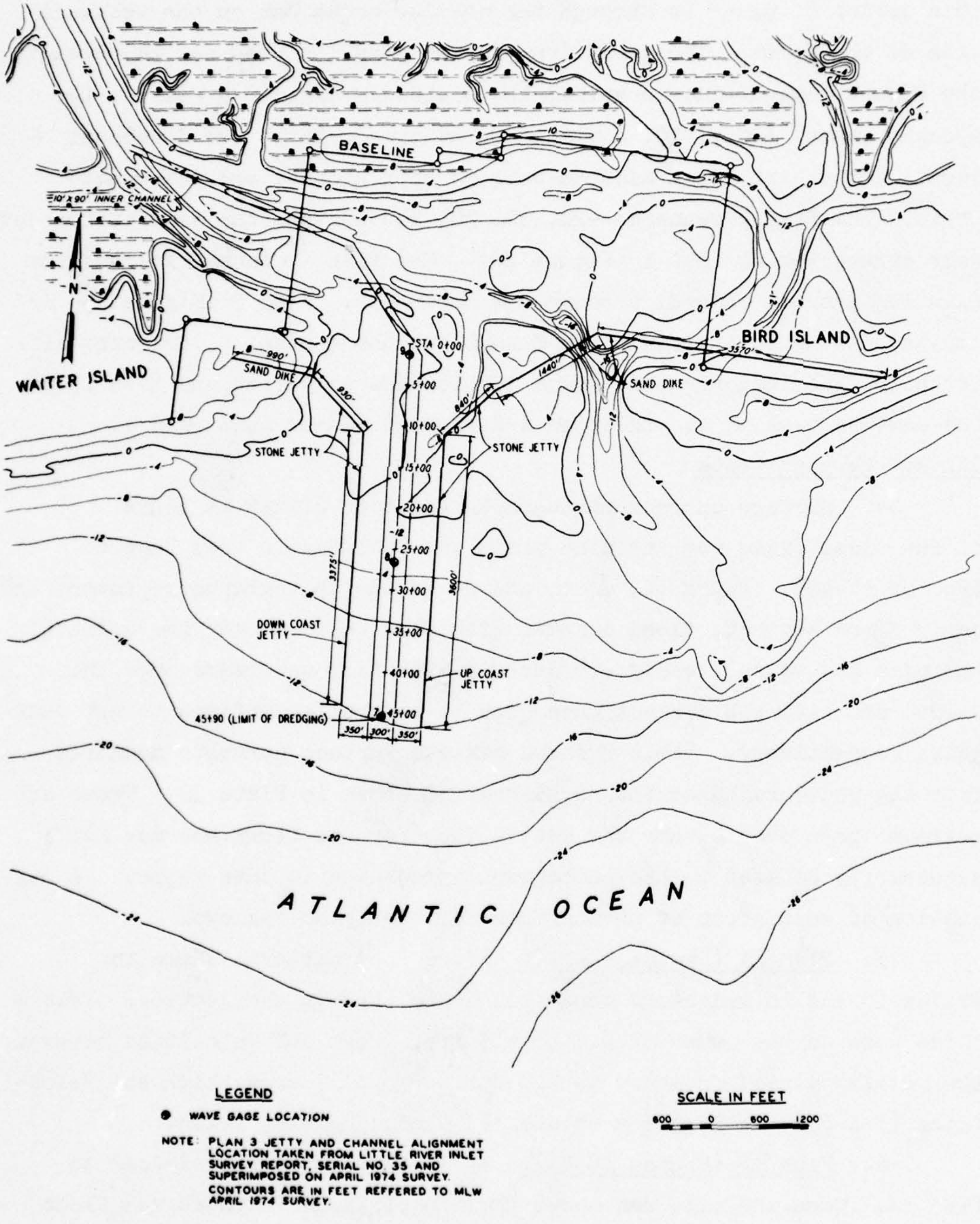



Figure 29. Jetty and channel alignment for Plan 3

Figure 27 shows Plans 1A, 1B, 1C, and 1D. The channel alignment for this series of plans is through the shallow ocean bar on the westward side of the inlet. The variations in the Plan 1 series can be noted in the figure legend--1A, no weirs; 1B, a midtide elevation weir on the upcoast (east) jetty; 1C, a midtide elevation weir on the downcoast (west) jetty; and 1D, a midtide weir on both upcoast and downcoast weirs. The Plan 2 sequence--2A, 2B, 2C, and 2D--has the same pattern of weir structures as Plan 1 (Figure 28). The Plan 2 channel follows the existing natural channel through the ocean bar. Plan 3 (Figure 29) is located in the same vicinity as Plan 1 but the channel is oriented differently, has longer rubble-mound jetties and no weirs, and ties into the eastern bank of the inlet in a different manner than Plan 1.

Surface current tests

44. Surface current photographs for four different hours of the tidal cycle for the nine plans are included in this report (Photos 14-49). Hours (4, 6, 9, and 0) of the photographs represent the early flood current, flood current with flow bayward over the weirs (if the plan has weirs), early ebb current with flow oceanward over the weirs, and late ebb current when flow is generally confined to ebb channels, respectively. Table 2 shows maximum surface currents measured from the photographs at the eight regions shown in Plate 39. These are maximums seen over either the entire flood or ebb flows and may not necessarily be seen in the photographs presented in this report. A discussion of each group of photographs for each plan follows.

45. Plan 1A (Photos 14-17). Flood flow patterns shown in Photos 15 and 16 indicated good flow lines through the jetties. Velocities were on the order of 3.5 to 4.5 fps. Peak ebb velocities between the jetties varied from 4.0 to 5.0 fps. Photo 17 shows high ebb velocities (3.1 fps) in Region 4 (Plate 39) along the east basin.

46. Plan 1B (Photos 18-21). Early flood flow was similar to Plan 1A. Once the tide was above the top of the weir there was flood flow over the deposition basin (Photo 20). Maximum flood flows were 4.0 and 4.3 fps. Photo 21 shows high ebb velocities along the east weir. Maximum ebb velocities range from 4.2 to 5.3 fps between the jetties.

47. <u>Plan 1C (Photos 22-25).</u> Early flood flow was similar to Plan 1A. Later in the flood, the flow over the west weir began (Photo 24). Velocities over the weir were 2.5 fps and did not appear to be excessive. During early ebb flow (Photo 25), there was some flow over the weir section; but once the water level was below the weir crest (Photo 22), flow was confined to the channels. Normally for mean tide, ebb flow over the weir lasted for 1 hr. Maximum ebb velocities between the jetties were about 5.0 fps. Moderate ebb velocities along the bayward side of the east weir were evident.

48. <u>Plan 1D (Photos 26-29).</u> Early flood flow was similar to Plan 1A. With the rising tide, flow over both weirs occurred (Photo 28). Maximum velocities over the weir sections were about 2.5 fps. Maximum flood velocities in the region between the jetties were 4.5 fps. During early ebb flow, there was more flow over the west weir than over the east weir because of the blocking effect of the large shoal behind the east weir section. There were velocities over 2.0 fps parallel to the weir (Photo 29). Late in the ebb, flow was confined to the deeper channels (Photo 26).

49. <u>Plan 2A (Photos 30-33).</u> Early and late flood flow patterns showed good alignment with the jetties (Photos 31 and 32). Maximum flood velocities between the jetties varied from 3.3 to 4.2 fps. Early ebb flow patterns (Photo 33) showed good flow alignment between the jetties, but a flow parallel to the downcoast sand dike and weir section had velocities up to 3.7 fps as it passed through the deposition basin. At late ebb flow (Photo 30), the flows were confined to deeper channels.

50. <u>Plan 2B (Photos 34-37).</u> Early flood flow was similar to Plan 2A. Late flood flow (Photo 36) showed flow over the east weir. Some of the flow approaching from the main channel was deflected through the west basin. Maximum velocities over the weir section were 1.8 fps. Maximum flood velocities between the jetties were 3.6 fps. During early ebb flow (Photo 37), there was flow along the interior portion of the west sand dike and weir section as in Plan 2A. Also, there was a slight deflection of ebb currents toward the bend in the east jetty. These effects disappeared for the late ebb flow patterns (Photo 34). Maximum

ebb velocities between the jetties were between 3.5 and 4.0 fps.

51. Plan 2C (Photos 38-41). Early flood (Photo 39) was similar to Plan 2A. Flow over the west jetty weir began during late flood (Photo 40). Maximum flood velocities between the jetties were 2.8 fps. Ebb flow conditions indicated flow along the west sand dike as noted for Plans 2A and 2B. Maximum ebb velocities varied from 3.5 to 4.1 fps between the jetties.

52. Plan 2D (Photos 42-45). Maximum flood velocities between the jetties were 2.7 fps. Maximum velocities over the weirs were about 1.5 fps. Early ebb had velocities along the west sand dike. Maximum ebb velocities between the jetties were 3.2 to 3.9 fps. During early ebb (Photo 45), flows attacked the bend in the rubble-mound portion of the east jetty. In the late ebb (Photo 42), flows were better aligned.

53. Plan 3 (Photos 46-49). Maximum flood velocities varied from 3.1 to 4.5 fps between the jetties. Maximum ebb varied between 3.3 and 4.8 fps.

54. The surface current velocity summary (Table 2) also showed maximum velocities farther bayward at Regions 5, 6, 7, and 8. Region 5 showed fairly consistent velocity maximums for all the plans, especially on ebb flow, so that no specific conclusions can be drawn except that maximum surface currents were usually in the range of 2.0 fps.

55. Region 6 (Plate 39) velocities were always measured directly behind the entrance channel. Flood flow velocities were slightly higher for Plan 2 orientations than for Plans 1 and 3. Ebb velocities were higher for Plan 2 because of the more easterly location of the jetties.

56. At Region 7 (Plate 39), comparison of Plan 1 ebb photographs with Plan 2 ebb photographs shows that ebb flow was in opposite directions. Plan 2 ebb flow direction was the same direction as for the base conditions. Also, the flood flows were in opposite directions for Plans 1 and 2. The maximum velocities were always in the east direction for both plans.

57. At Region 8 (Plate 39), velocities were low for both ebb and flood flows for Plans 1 and 3 and were high for Plan 2. Flood and ebb maximums for Plan 2 were about 3.5 fps.

Wave tests

58. Wave heights in the entrance channel and deposition basin regions were measured for two wave directions--south and S58°E. In each case, a 7-sec period was selected as representative for waves of the region. The ocean wave heights were measured in front of the wave generators shown in Plate 40. The measuring stations for each plan are shown in Figures 27, 28, and 29. Plate 41 summarizes wave heights for a 4.6-ft ocean wave from the south. The wave heights shown are averages of four gage readings taken at high water, at low water, during maximum ebb current, and during maximum flood current; actual readings are shown in Table 3. Plate 42 and Table 4 give similar data for a 4.8-ft S58°E wave.

59. For the south wave (Plate 41), wave heights for the most oceanward gage between the jetties (Gage 7) were considerably higher for Plans 1 and 3 than for Plan 2. The differences at sta 8 were small; and for all the bay stations, the differences in wave height were also small. Thus it appeared that for a south wave, location of the Plan 2 jetties was more preferable. Table 3 shows that maximum wave heights in all cases occurred in the channel during the maximum ebb when the greatest wave-current interaction takes place. It should be remembered that only refraction was being reproduced accurately and scale effects of unknown (but believed to be small) magnitude would occur due to wave diffraction.

60. For the S58°E wave (Plate 42), waves for the Plan 1 and Plan 3 jetty system generally had smaller values than those for Plan 2, except at Gage 8 (where wave heights were about the same for all plans). The differences in wave heights between plans for this wave direction, which favored Plan 1 or 3 over Plan 2, were not as great as the differences in height for the south waves, which favored Plan 2 over Plans 1 and 3. Because of this, on the whole, Plan 2 had a better location and orientation than Plans 1 and 3 for the tested wave conditions.

Wave photographs

61. High- and low-water photographs of waves approaching the inlet region, for the two wave directions discussed above, are shown for

Plans 1D, 2D, and 3 in Photos 50-61. For Plans 1 and 2, the D version of each plan was photographed to show wave activity behind both the east and west weir sections.

Discussion

62. After examination of the preliminary test data, a selection was made of the plan that would provide optimal hydraulic conditions and be economically satisfactory. Due to the results of the littoral drift analysis made by the Charleston District (which indicated reversing drift with both east and west drift of significant magnitudes), it was decided that a two weir system would be required. There were no negative aspects of the hydraulic data to discourage this decision. Weir elevations of midtide level (+2.3 mlw) were noted in the model to provide good flood-ebb flow asymmetry. This means that for a mean tide, flood flow over the weir occurred only for 3 hr of the tide cycle and ebb flow over the weir occurred for only 1 hr. Flood flow over the weir is desirable to aid wave action in bringing sediment over the weir into the deposition basin. A quick cutoff of ebb flow over the weir is desirable for two reasons. First, ebb currents in the basin would tend to remove material from the basin region. Second, most of the ebb flow would be confined between the jetties to give additional discharge to maintain channel depths.

63. Positive and negative aspects of each plan group are listed in Table 5. Due to the desirability of weirs on both sides of the inlet, Plans 1A, 1B, 1C, 2A, 2B, 2C, and 3 were eliminated from further consideration. Comparisons were then made between Plans 1D and 2D. Both plans showed good flow patterns over the weirs and between the jetties (Figure 30). Plan 1D maximum velocities between the jetties were from 1.3 to 1.6 fps higher than those for Plan 2D. In considering that a mean condition was being tested (mean ocean tide and mean inflow from the AIWW), the Plan 2D maximum ebb velocities at Regions 1 and 2 (Plate 39) of 3.2 and 3.9 fps, respectively, are probably in a safer range for small-craft navigation. Also, the slower flood velocities for Plan 2 would be less likely to bring in sediments from outside the jetties to the channel region. Ebb flows between the jetties were well

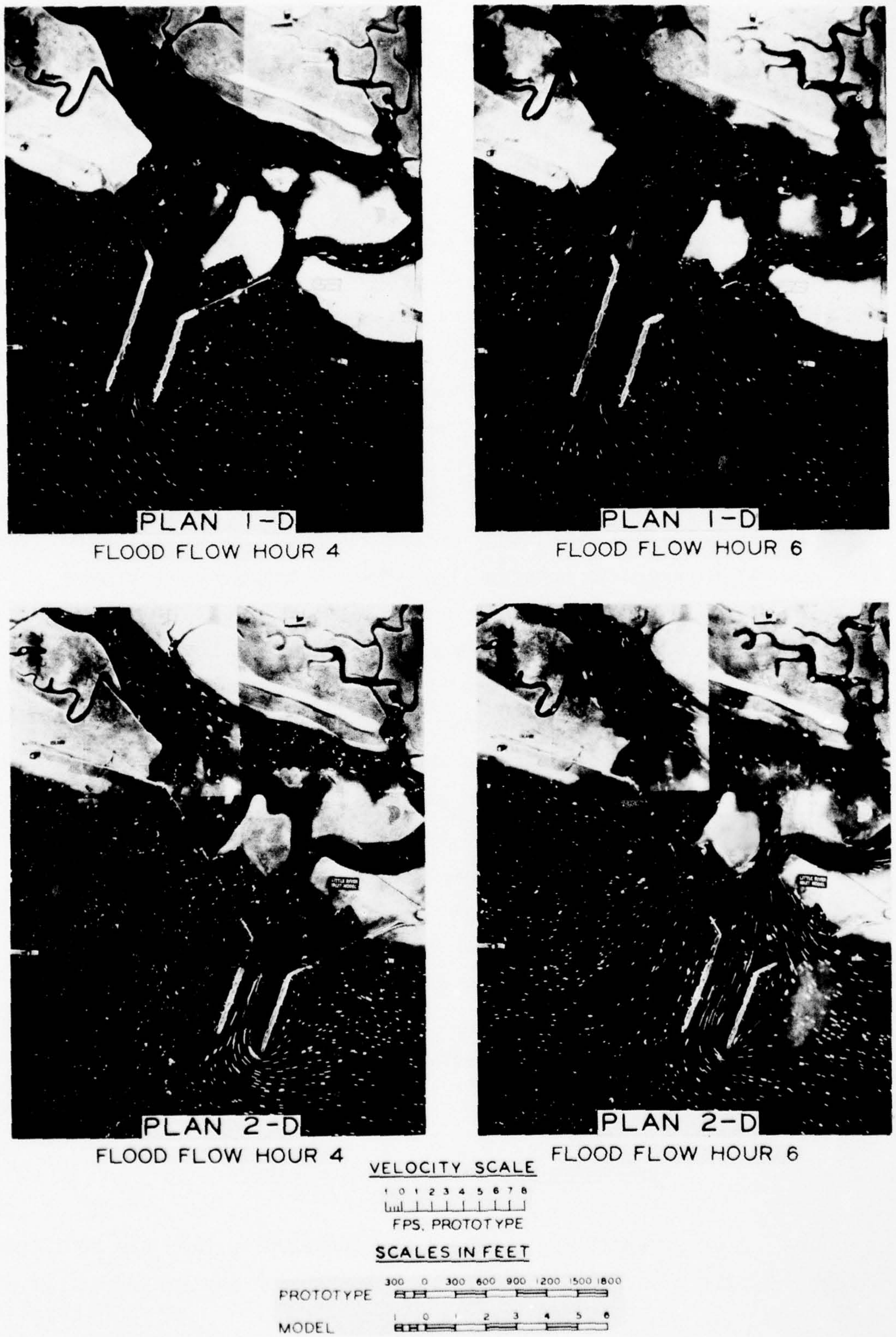



Figure 30. Surface currents

aligned with the navigation channel as shown in Figure 31 for both plans. A slight impingement of ebb currents on the bend in the east jetty at hour 9 for the Plan 2D jetty was seen during early ebb due to the temporary ebb flow condition at the east weir. This lasted for only 1 hr of ebb flow. Both Plans 1D and 2D showed some problems with respect to ebb currents flowing parallel to the sand dikes toward the deposition basin (Photos 29 and 45). For Plan 1D, the ebb currents flowed toward the east basin; and for Plan 2D, the currents approached the west basin. For either case, however, these problems could be alleviated by placing material dredged from the basin between the basin and the channel to a level above high water which would prevent these currents from occurring, or spur dikes could be placed perpendicular to the sand dikes to deflect ebb flow away from the basin.

64. The limited wave tests indicated that Plan 2D was better than Plan 1D. With regard to construction, Plan 2D had advantages over Plan 1D. Plan 2D was located along the alignment of the existing natural channel so that limited dredging of the design channel between the jetties would be needed as compared with Plan 1D. The rubble-mound portion of the jetty system was shorter for Plan 2D than Plan 1D, since the distance to the -12 ft contour was shorter. Plan 2D avoided the problem of building a sand dike across the existing channel.

65. Based on observation of surface current patterns, it appears that existing bay circulation would be more nearly maintained with Plan 2D than Plan 1D. Flood and ebb velocity directions were reversed at Region 7 (Plate 39) for the Plan 1D system when compared with the base condition, but the directions were similar to the base for the Plan 2D system.

66. Based on the above considerations, Plan 2D was selected for more detailed testing.

## Hydraulic Testing of Plans 2D and 2D1

67. Plan 2D which was selected for detailed testing was modified slightly by the placement of a fill area bayward of the west basin as

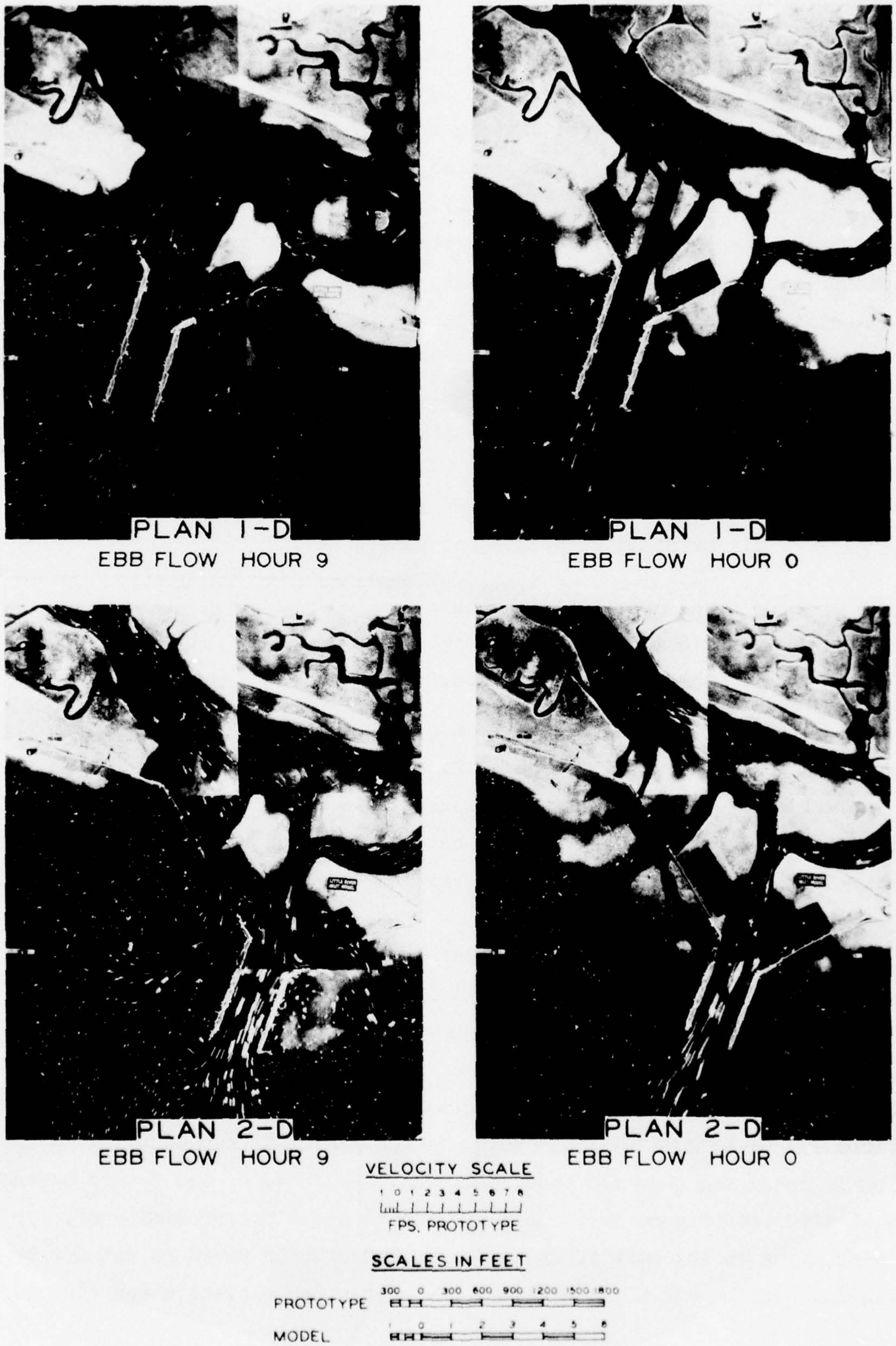



Figure 31. Surface currents

shown in Figure 32. The area would consist of material dredged from the basin and placed up to or above the level of high tide. This was done to prevent ebb currents from cutting through the basin as had been observed in the preliminary tests. Also, during the detailed testing, a request was made by the Charleston District to evaluate the effect of shortening the jetties, so that in Plan 2D1 they extended to the -8 ft contour instead of the -12 ft contour. This would result in a considerable construction cost savings if technically satisfactory. Figure 33 shows a view of Plan 2D as one looks oceanward. This photograph was made before installing the fill area (discussed above) which was located in the region to the right of the basin that is on the right side of the entrance channel.

68. Data collected for Plan 2D included:

a. Detailed velocities at Ranges 1-7.

b. Velocities at auxiliary stations near the jetties and in the navigation channel.

c. Tidal data at sta 1-13.

d. Sediment tracer tests.

69. After hydraulic data from Plan 2D were collected, the jetties were shortened to extend to the -8 ft contour instead of the -12 ft contour. The effects of this shortening on tidal heights, velocities at selected locations, and surface current patterns were evaluated by comparing these data with data for the longer jetties.

Plan 2D results

70. Tidal heights. The effects of Plan 2D on tidal heights compared with the base condition (April 1974) are shown in Plates 43-47; and Table 6 shows phase shifts, high-water differences, low-water differences, and tide range differences for the bay tide gages. Average tide elevations for each gage compared with the base are shown in Table 7. These data indicate that Plan 2D generally caused a 10- to 15-min phase lag from the base condition. Gages 4, 5, and 6 were those most affected (Figure 34). This was due to the close proximity of these gages to the part of the inlet entrance which would be cut off by the sand dike. For all the gages, the high-water elevation was reduced

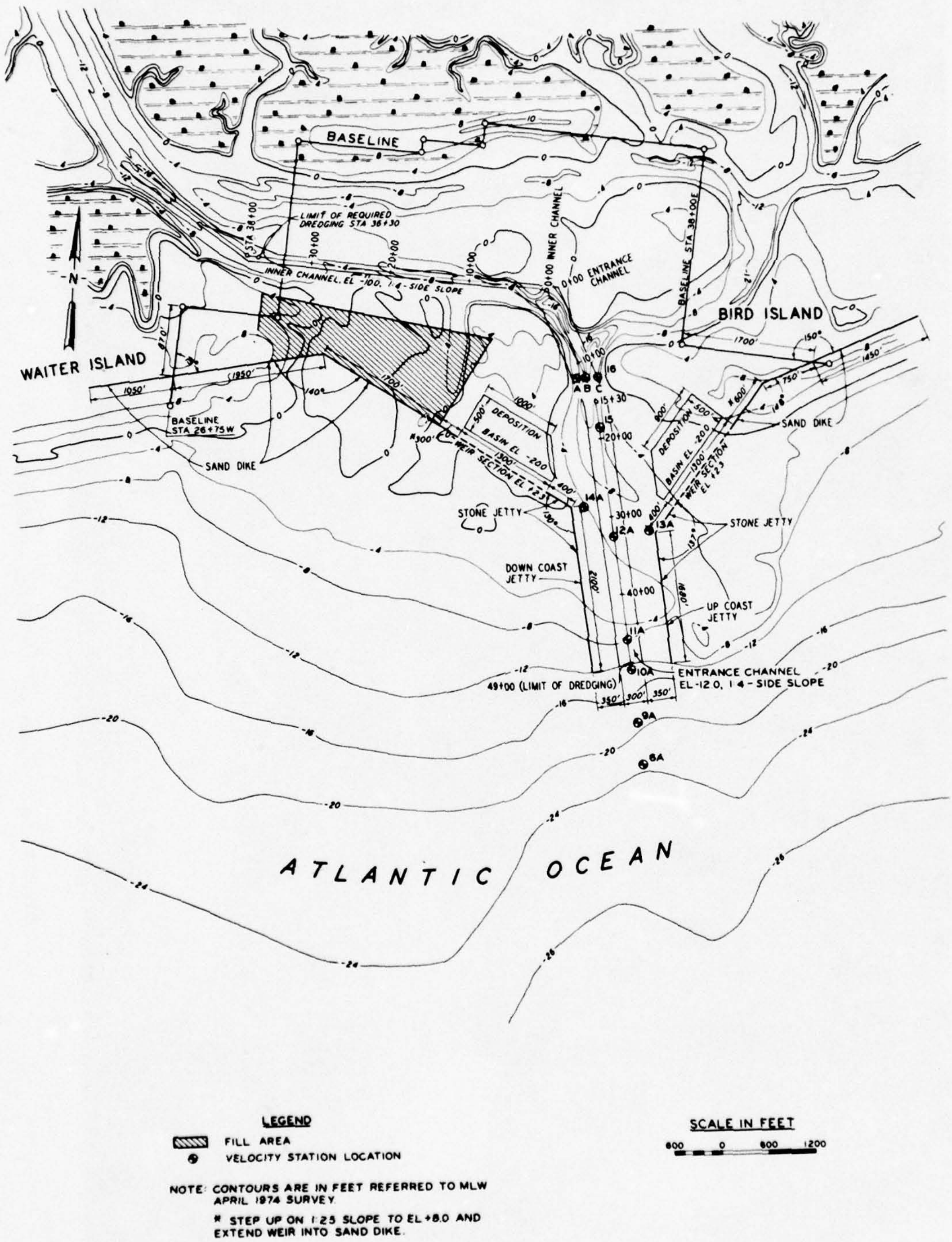



Figure 32. Jetty and channel alignment for Plan 2D

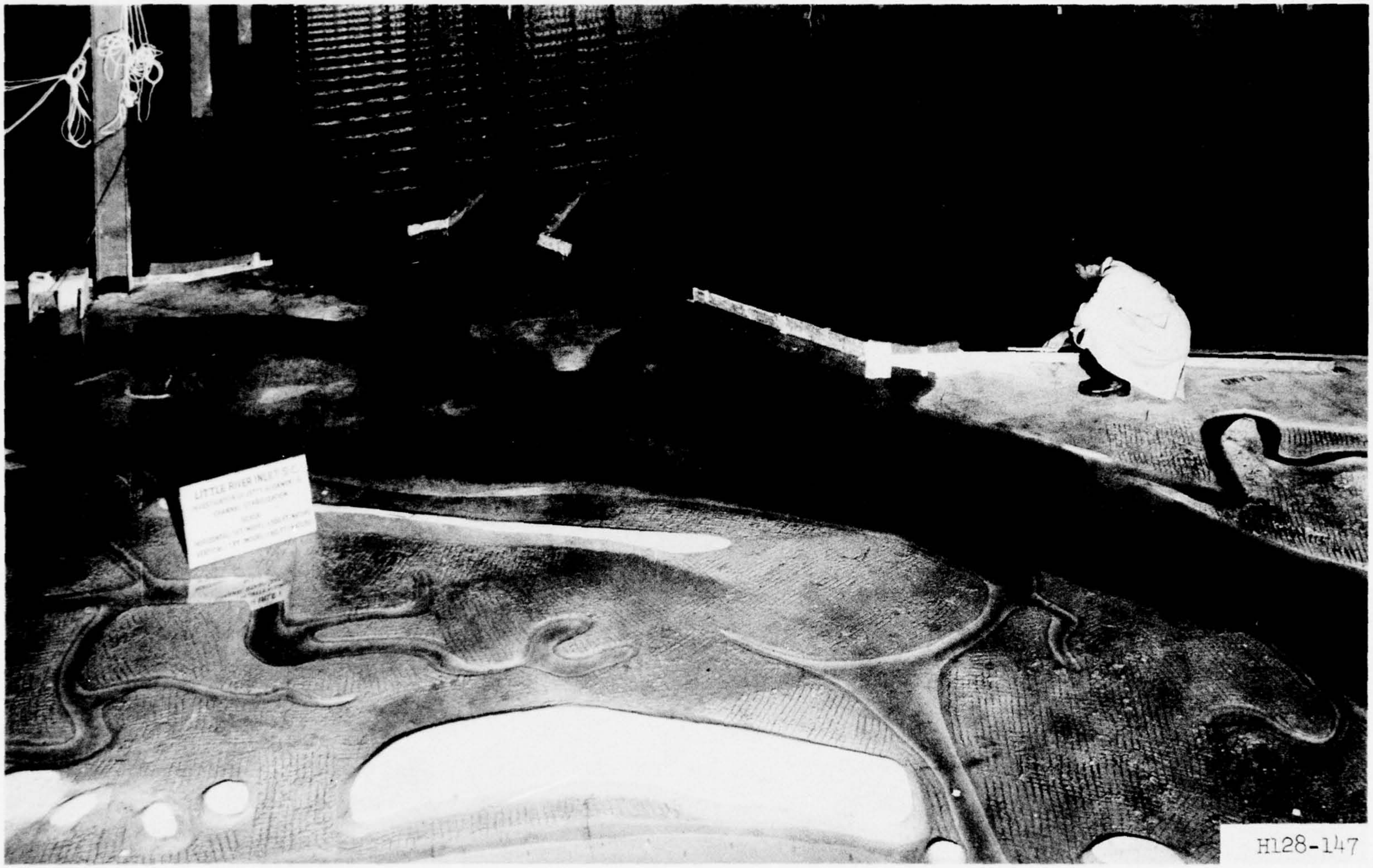
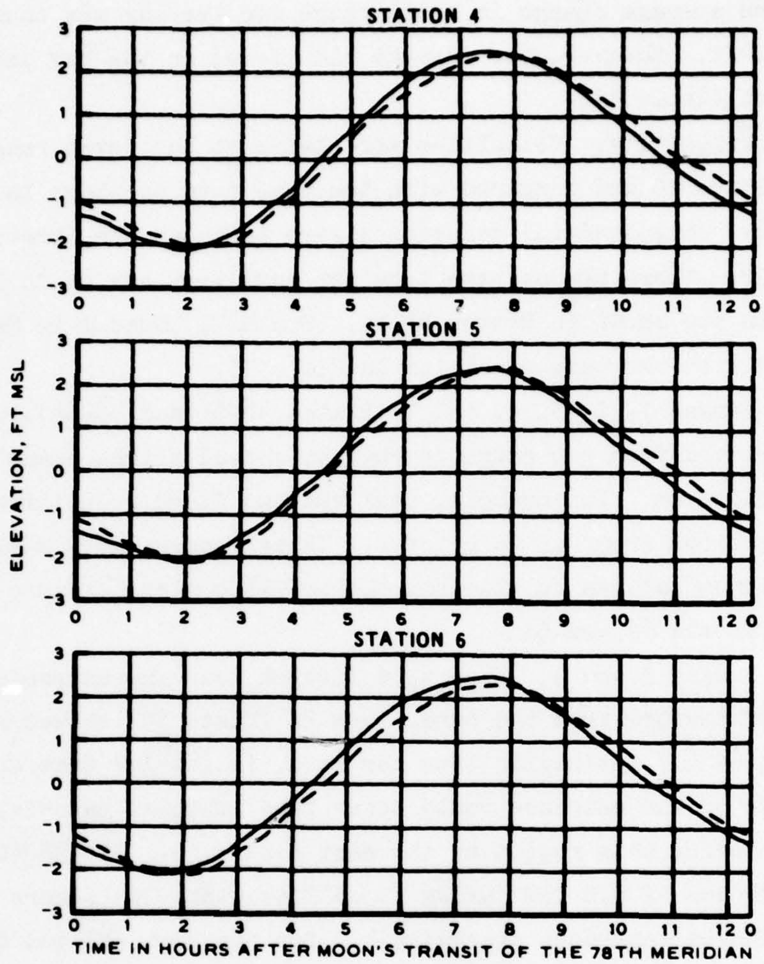



Figure 33. Plan 2D looking oceanward




TEST CONDITIONS
OCEAN TIDE RANGE = 5.0 FT

LEGEND
——— BASE
– – – – PLAN 2D

STATIONS
4, 5, AND 6

Figure 34. Effects of Plan 2D
on tidal heights

on the average of 0.1 ft. Low water remained the same as the base condition. The average change in tidal range for the bay was thus a reduction of 0.1 ft. However, the average tide level in the bay increased only 0.01 ft (Table 7).

71. Velocities. Velocities were taken at the seven ranges (1-7) shown in Figure 20 and compared with the base data as shown in Plates 48-64. Supplemental velocities were taken at the locations shown in Figure 32. There are no base data for auxiliary sta 8A to 16C; only Plan 2D data are shown in Plates 65-74. Sta MAD, located in Mad Inlet, is compared with the base condition in Plate 75.

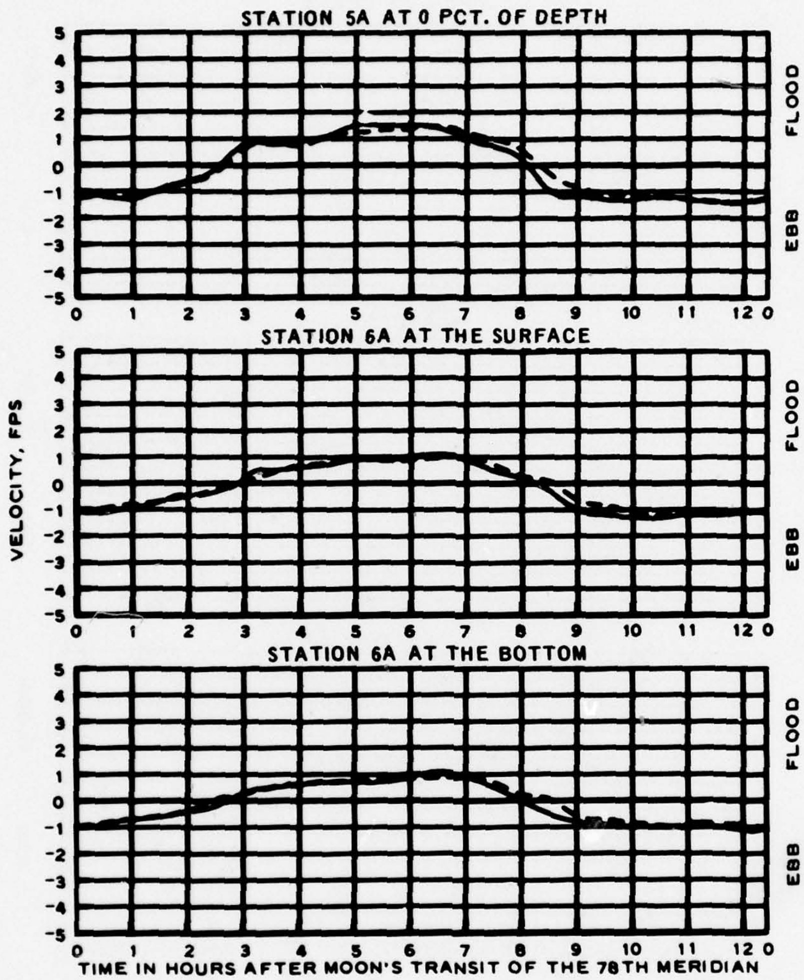
72. Ranges 1, 2, 5, 6, and 7 (Plates 48-51 and 58-64), which are somewhat removed from the entrance region, showed slight changes from the base condition. For example, peak ebb and flood velocities showed slight reductions from 0.1 to 0.5 fps. These changes were small but the trend was almost always to slightly slower velocities. Figure 35 shows velocities at sta 5A and 6A.

73. Ranges 3 and 4, which were located near the entrance, showed the greatest changes from the base. Sta 3A (Plate 52) showed maximum ebb velocities 1.7 fps higher than the base, indicative that scour on this side of the entrance would occur once littoral material is cut off from entering this region by the east sand dike. Sta 3B (Plate 53) showed increases of 2.0 fps during flood flow. Sta 3C (Figure 36 or Plate 54) showed increases averaging 1.0 fps for both ebb and flood flows.

74. At sta 4A (Plate 55), located in a predominantly ebb channel, maximum ebb and flood velocities were increased by 0.7 and 1.3 fps, respectively, at the surface. Sta 4B and 4C (Plates 56 and 57) showed only minor changes.

75. Velocities for Plan 2D showed the greatest change in the vicinity of the entrance gorge. These increases occurred because the entrance had been considerably narrowed. From the velocities, it would appear that some scour in the vicinity of Range 3 and sta 4A may take place, enlarging the flow area bayward of the base of the jetties.

76. Sta 8A, 9A, 10A, 11A, 12A, and 15A follow the center line of




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

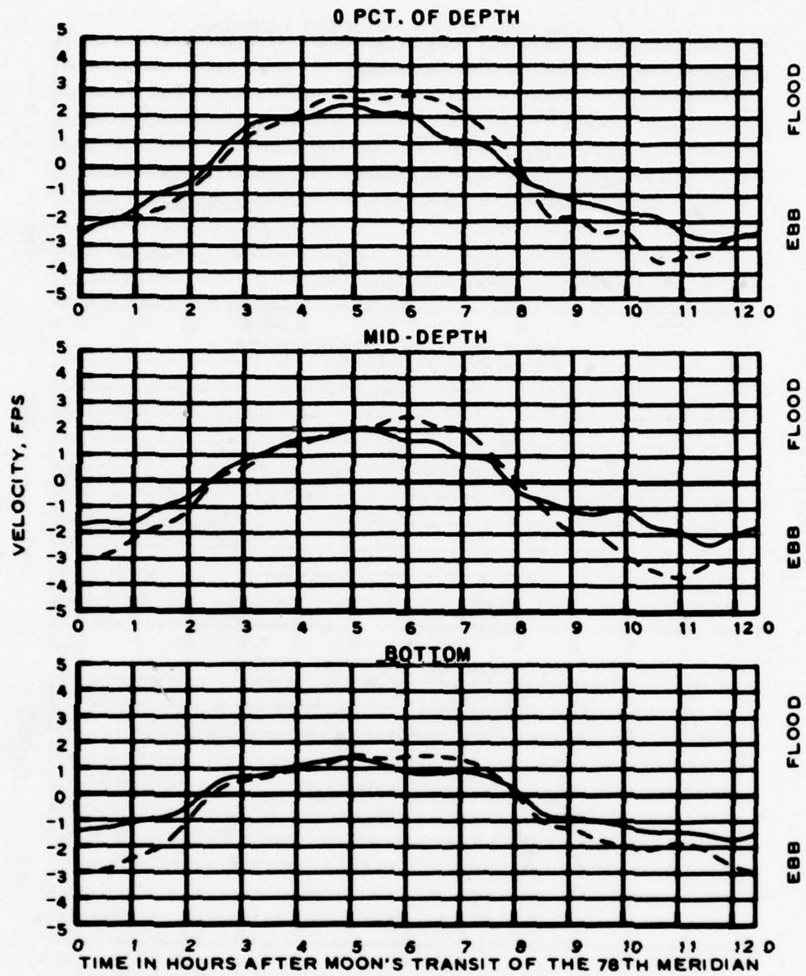
LEGEND

——— BASE

– – – – PLAN 2D

STATIONS
5A, 6A, AND 6A

Figure 35. Effect of Plan 2D on velocities




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

- - - - PLAN 2D

Figure 36. Effects of Plan 2D on velocities at sta 3C

the channel from the ocean to the bay. Velocities for these stations are summarized in Table 8. Sta 8A (Plate 65) at the -24 mlw contour had ebb velocities up to 2.2 fps on the surface and 1.2 fps on the bottom. Data at sta 9A (Plate 66) indicated that only very small flood velocities existed at the -20 ft mlw contour, and ebb velocities were about 50 percent greater than those at sta 8A. Maximum bottom ebb velocity was 1.6 fps and maximum surface ebb velocity was 3.0 fps. Sta 10A (Plate 67) showed slightly faster flood and ebb velocities than did sta 8A or 9A. Sta 11A (Plate 68), located right at the entrance, had maximum surface velocities of 2.0 fps (flood flow) and 3.0 fps (ebb flow) and bottom ebb of 2.0 fps and flood of 1.8 fps. Sta 12A (Figure 37 and Plate 69) was similar to sta 11A, except for slight increases of maximum velocities. Sta 15A (Plate 71) located farther bayward had

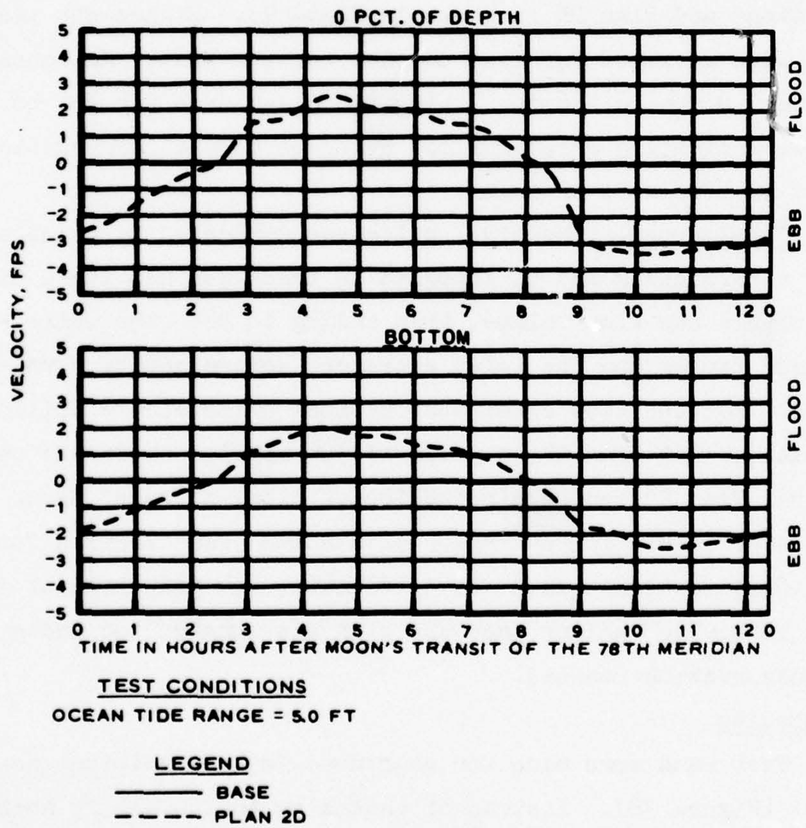



Figure 37. Velocities in entrance channel between Plan 2D jetties at sta 12A

slightly faster velocities than did sta 12A. All stations along the channel center line are ebb-dominant; thus, ebb velocities were greater than flood velocities, indicative of good flushing action for material in the channel.

77. Sta 13A and 14A, located near the bayward ends of the rock rubble-mound east and west jetties (Figure 38), showed maximum ebb and flood velocities of about 2.0 fps (Plates 70 and 71).

78. Sta 16A, 16B, and 16C velocities were taken near the narrowest cross section in the inlet gorge (deepest portion of the channel). Flood flow was uniform across the cross section (Plates 72-74). Maximum ebb and flood velocities were about 4.0 fps for each depth and station. Ebb velocities also indicated a uniform flow across the cross section.

79. A comparison of surface velocities through Mad Inlet between base conditions and Plan 2D is shown in Plate 75. Higher ebb and flood velocities were measured for Plan 2D than for the base. Maximums increased from 3.0 fps to 4.6 fps during flood and from 2.8 fps to 4.0 fps on ebb flow, indicating greater flows here due to the construction of the jetties at Little River Inlet.

80. Tidal prism. The tidal prism was estimated by calculating discharges for ranges 2 and 5, integrating these ebb and flood discharge curves to obtain the flow volume, then adding to both the water stored between these ranges and the inlet entrances determined by a volumetric calculation. For the base condition, a tidal prism of 477 million cu ft was calculated. For Plan 2D, a prism of 426 million cu ft was calculated. Thus, Plan 2D caused a reduction of tidal prism of about 11 percent. If scour occurs in the region of minimum cross section for the plan as velocities at Ranges 3 and 4 indicate, the reduction of prism would most likely be smaller once the plan was constructed and a stable minimum cross section reached.

### Plan 2D1 results

81. Test runs were made for shortened jetty conditions described as Plan 2D1 (Figure 38). Instead of extending to the -12 ft contour, the jetties were extended only to the -8 ft contour, thus reducing total jetty lengths by 930 ft. This reduction is contrary to the

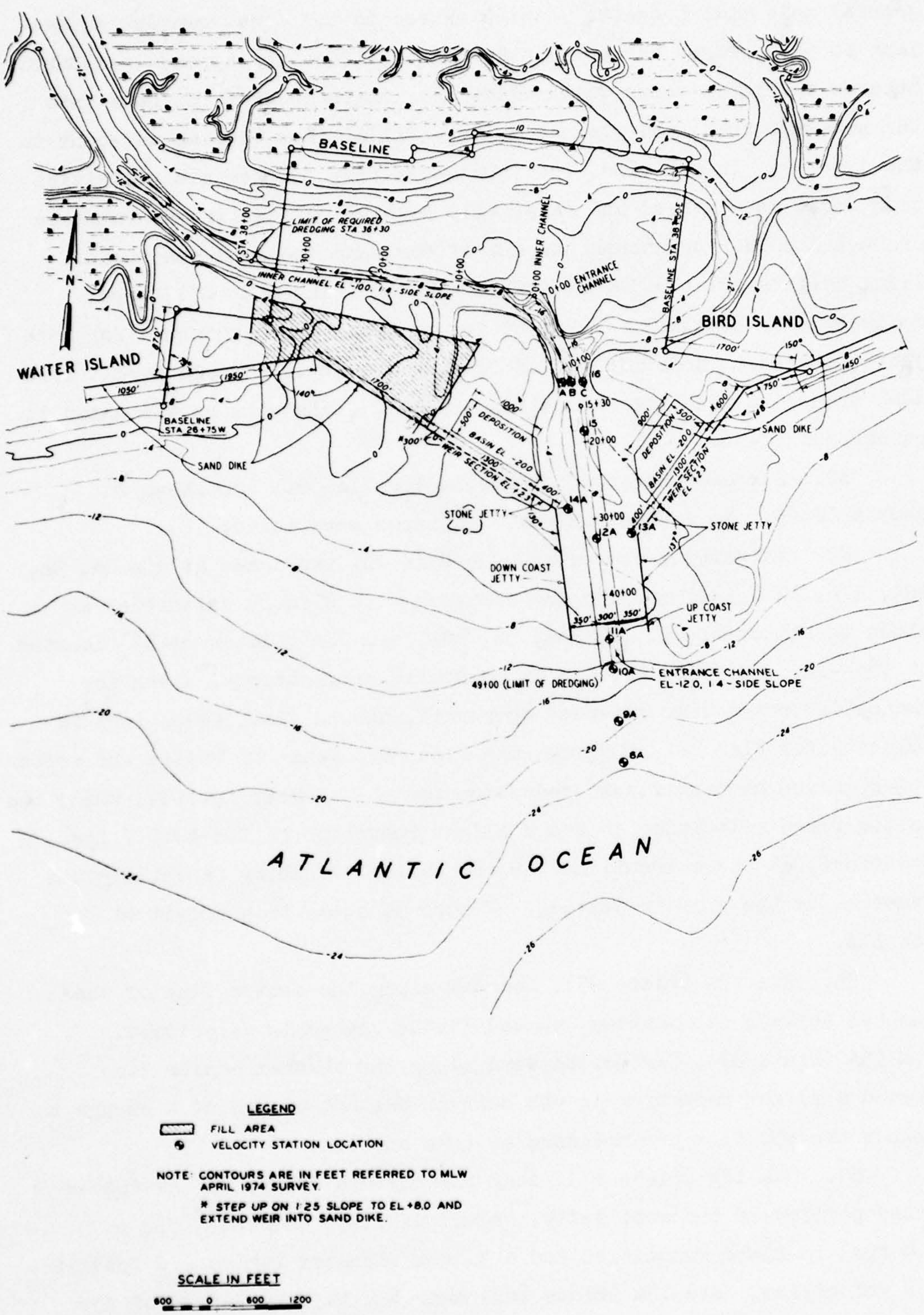



Figure 38. Jetty and channel alignment for Plan 2D1

general rule that suggests jetties extend to the ocean contour equivalent to the dredged channel depth. The modification appears reasonable because the jetty weirs would allow the longshore drift to pass into the sediment traps and prevent a large fillet from forming adjacent to the jetties. In addition, the imbalanced flow (higher ebb velocities than flood velocities) and relatively high velocities in the entrance channel should flush sediments out of the entrance into the ocean. Tidal heights (Plates 76-80) and velocities (Plates 81-87), were collected for Plan 2D1. Sediment tracer tests were performed for both jetty lengths to determine if shortening the jetties would permit more sand transport into the navigation channel. This will be discussed in paragraphs 87-96.

82. Surface current photographs for Plan 2D1 are shown in Photos 62-65. No unusual velocity patterns were noted.

83. Velocity measurements for Plan 2D1 were made at sta 8A, 9A, 10A, 11A, 12A, 14A, and 15A and compared with Plan 2D velocities as shown in Plates 81-87. Sta 8A, 9A, 10A, and 11A (Plates 81-84) located at the -24, -20, -16, and -12 ft contours, respectively, along the channel's center line extended oceanward, showed small reductions in velocity for Plan 2D1 compared with Plan 2D. Plan 2D1 bottom ebb velocities showed no significant reduction for the shorter jetties, while the bottom flood velocities showed a slight reduction of 0.3 to 0.7 fps. Therefore, at these locations the ebb current flushing capability was enhanced by the shorter jetties. Figure 39 shows this effect at sta 11A.

84. Sta 12A (Plate 85), located along the center line of the channel between the jetties, showed little change in velocities. Sta 15A (Plate 87), farther bayward along the channel center line, showed a slight reduction in ebb current but not enough of a change to reduce the ebb flow predominance at this station.

85. Sta 14A (Plate 87), near the bayward corner of the rubble-mound portion of the west jetty, showed a slight decrease (0.2 to 0.4 fps) in flood velocities and a slight increase (up to 1.0 fps) in ebb velocities. Sta 13A (Plate 86), near the bayward corner of the

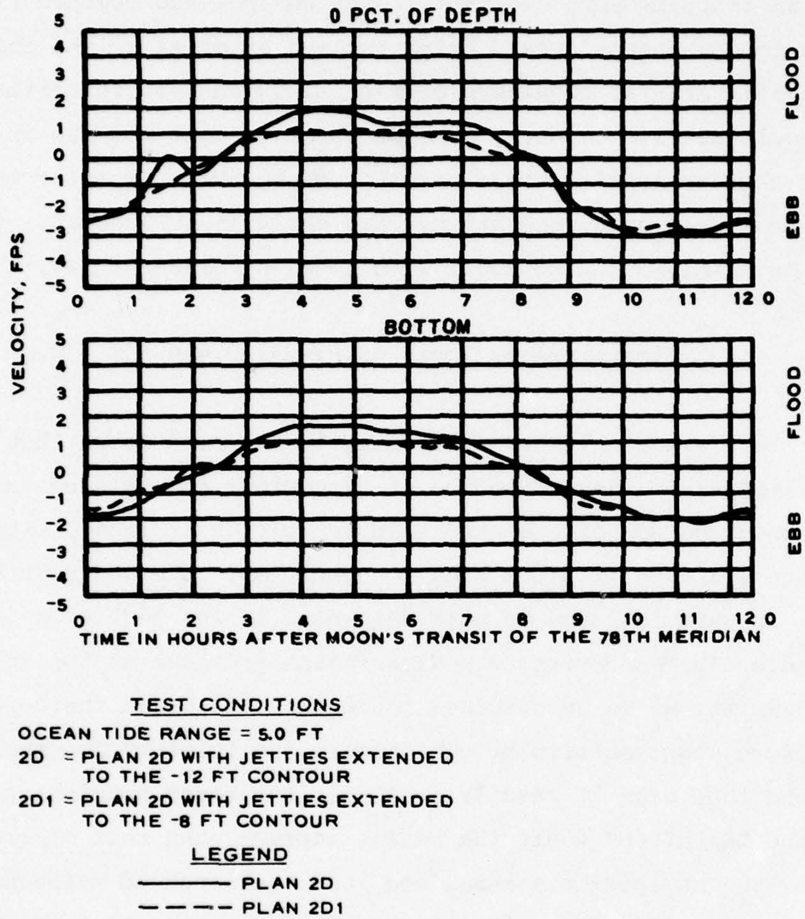



Figure 39. Velocities between the jetties for Plans 2D and 2D1 at sta 11A

east jetty, shows small overall reductions in velocities.

86. Tidal heights were measured at all stations for the shortened jetties. Plates 76-80 show that reduction of the jetty length produced no significant change in tidal heights or phases. The overall effect of reducing jetty length on the hydraulic conditions compared with the longer jetty system appeared to be slight. Flow patterns and velocities indicated that flood velocities in the navigation channel would be slightly reduced (0.2 fps to 0.4 fps) with slightly increased flow over the weirs. Ebb velocities were almost unchanged. Each of these changes would be in a favorable direction, since increased flow over the weirs

would aid in trapping more sediment in the basins, and reduced flood velocities in the channel would bring in less material to the channel. With a slightly greater imbalance between flood and ebb velocities, more sediment could be flushed out. A major question that remains is whether or not the shorter jetties would permit more material to enter the channel than the longer ones when strong wave activity is present. This question was examined in the model with sediment tracer tests.

## Sediment Tracer Tests of Plans 2D and 2D1

87. In previous hydraulic testing, it had been noted that shortening the jetties of Plan 2D to the -8 ft contour (identified as Plan 2D1) produced no notable change in velocities or tidal heights in the bay when compared with the Plan 2D condition. The sediment tracer tests were in part intended to help determine if the reduction in jetty lengths would cause undesirable sedimentation problems at the inlet entrance. Questions to be examined included: (a) Would the deposition basins capture sedimentation brought toward the inlet by longshore currents and thus make it readily available for beach nourishment by dredging the basin? (b) Would the basins capture sand that otherwise might enter the navigation channel and lead to increased maintenance of the channel? (c) With the existence of weirs on both sides of the channel, could the jetties be shortened to reduce construction costs? (d) Would there be a major difference in the amount of sediment entering the channel from the oceanward end if the jetties extend to the -8 ft contour instead of to the -12 ft contour?

### Approach

88. Ideally, a fully movable-bed model would be desirable to study sedimentation in the inlet entrance. However, this is very time- and cost-consuming and the state of the art is such that only trial and error procedures may be followed. An alternative approach is the use of the "tracer model." As discussed by J. W. Kamphuis,[11]

> One viable solution to modeling a three-dimensional problem is the "tracer model," which is a fixed-bed

model covered with a veneer of *lightweight material.* This model will show correctly the areas where sediment motion takes place and the direction of motion (if scaled correctly), however, the quantities of material moving and deposited will not be correct. It certainly constitutes an inexpensive alternative to the completely mobile bed model which will give no better answers unless scaled very carefully.

89. During the sedimentation study, three procedures were used. The first involved emplacement of a layer of plastic sediment particles on the model bed in Regions 2-4 and 8-10 shown in Figure 40. This was

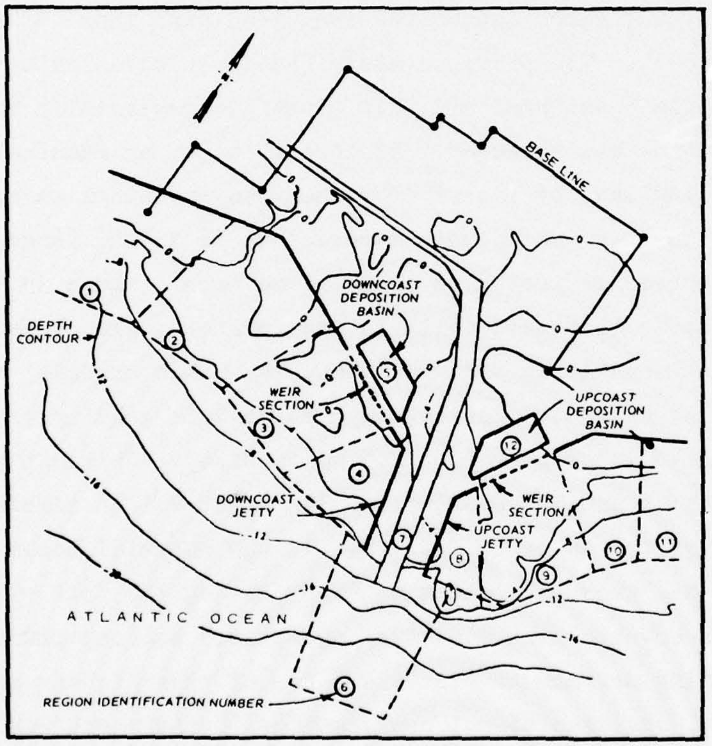



Figure 40. Location of model sediment regions

done before starting model operation. The tide control mechanism and one wave generator were then turned on and operated for six tidal cycles. The sediment movement was carefully observed during operation, and a sketch of the final location of the material was made. The second procedure involved the injection of a sediment tracer in the surf zone either east or west of the study area, the location dependent on the

wave direction used for the given test. Sketches and photographs were made noting the direction of movement of the material. Also, movies were taken of this type of test for both eastward and westward wave directions. The third procedure was the observation of the wave- and tide-generated currents by the use of dye. Sketches were made of the circulation patterns resulting from the test conditions.

90. The material chosen for the tracer testing was a plastic cube, about 3 mm on a side, with a specific gravity of 1.18. This material had been successfully used in a previous model study of Masonboro Inlet, N. C., which had scales identical with those of the Little River Inlet model. The previous study had included an extensive search for an appropriate material and this plastic, commercially called Tenite butyrate plastic, was selected. Since that time, an examination of sediment scaling laws by Yalin[12] for short waves, tidal waves, and unidirectional flow have shown this material to be in the range necessary to simulate correctly prototype sediment movement. Late in the testing a lighter plastic material, still in the correct range of sediment type, was found to be available and was also used. This material was lighter than the Tenite butyrate plastic, with a specific gravity of 1.05, and was more rodlike in shape (about 2.5 mm in size). This material was more difficult to use, however, since its light weight allowed the surface tension of the water to lift it. If the material became exposed in an intratidal area it would float away during the next rising tide unless it was covered with a wetting agent such as soap powder which aids in breaking surface tension. The use of this lighter material, as it turned out, gave additional confirmation of the tests run with the Tenite butyrate plastic. A third material, a glass bead known commercially as microbeads, was found to be too heavy for the purposes of the testing. The specific gravity of this material was 2.42 with a diameter in the range between 0.062-0.088 mm.

Test conditions

91. The ocean tide for all tests was set to the average range of 5.0 ft, and the ocean short-period gravity waves were varied. Two 60-ft-long wave generators were used in the model to produce the waves

(Figure 14). A 7.0-sec period was modeled for all tests and was consistent with prototype wave periods occurring in the Little River Inlet region. Three wave directions were chosen, S58°E, south, and S34°W, in order to represent a wave in the westerly direction, a wave about normal to the entrance area, and a wave in the easterly direction (Figure 41), respectively. The wave height used throughout most of the testing was about 5.0 ft (one test used 7.5-ft waves) which represented a storm wave. Under this condition there should be significant material movement, especially in the more oceanward locations of the jetty tips and the entrance to the navigation channel. These areas are of particular interest for comparisons of the effects of different jetty lengths on the sediment transport. Tests with wave heights on the order of 2 to 3 ft (about the average wave height for this region) were run also.

Test results

92. Twenty sediment study tests were conducted. In order to facilitate presentation and discussion of the test results, each test is described on an individual plate--including test conditions, type of test, and a short discussion of results--and then followed by an illustrative plate showing direction of sediment (or current) movement and final location of the material at the end of the test (Plates 88-125). Figure 40 shows the location of the important elements of the plan and region identification numbers referenced in the test discussions.

93. In order to examine the effect of jetty length on sediment movement, comparisons can be made between tests 18 and 14 for the S34°W wave, tests 4 and 1 for the south wave, and tests 8 and 9 for the S58°E wave. These sediment tracer tests, in which the material was spread uniformly over most of the study area at the start of the test, examined how material will move immediately after construction of the jetties. Based on direct observations during tests 18 and 14 (both jetty lengths) and the results presented in Plates 112-113 and 120-121, traces of the material placed in block 4 moved around the west jetty tip with the flood current, then back out on the ebb where the material was then pushed eastward by waves at the outer end of the jetty into blocks 8 and 9. Some of this material moved into the east basin (i.e., Region 12)

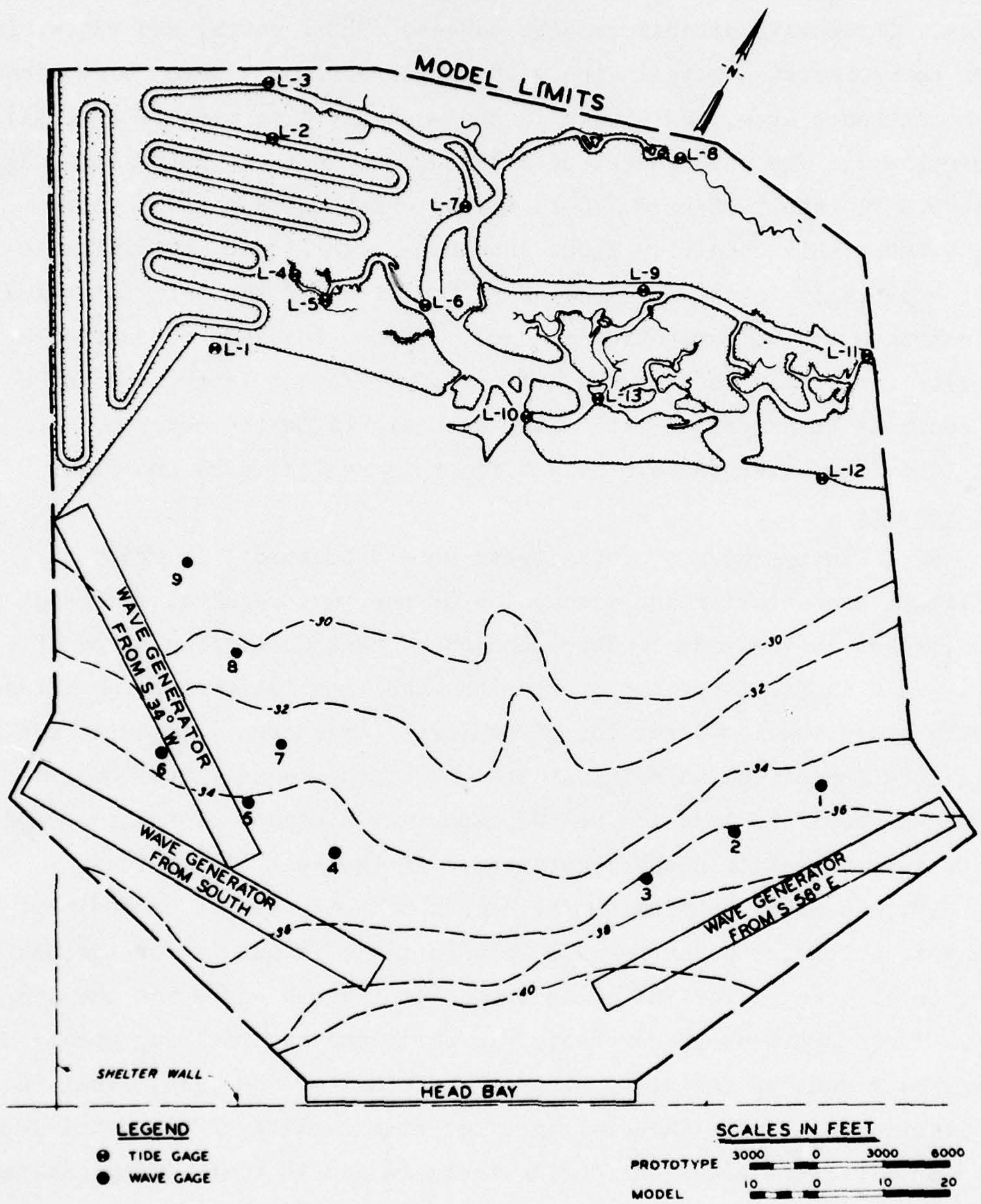



Figure 41. Model layout with wave generator locations

or moved along the east beach. Also, material moved into the west basin (Region 5) from Regions 2, 3, and 4 during flood flow. For the south wave, there was no movement across the channel but there was trace movement oceanward during ebb flow from Region 4 into Region 6 (see tests 1 and 4, Plates 88-89 and 92-93). Again there was movement into both basins for both tests. Most movement into the westerly basin (Region 5) was from Regions 3 and 4. Material from Region 9 entered the west basin (Region 12). With the S58°E wave there was some transport of material from Region 8 (tests 8 and 9, Plates 100-103) to Region 6 and then into Region 4. The movement of material around the jetties was confined to material that came from Region 8. Material in Regions 9 and 10 moved toward the weir jetty with some material moving into the basin Region 12 and some material accumulating in Region 8 near the weir section. Also, material from Regions 3 and 4 moved into the west basin, Region 5. It should be noted this was for a 5-ft wave condition, which is typical of storm conditions. Again there was no difference in the results due to jetty length.

94. The littoral drift injection tests, which followed the movement of material continuously injected into the surf zone either east of the east jetty or west of the west jetty (depending on wave direction), were also performed for the two jetty lengths. With a S34°W wave (tests 16 and 17, Plates 116-119) most of the littoral material filled in the trough area that was formerly a channel off of Waiter Island in Region 2. Some material worked its way along this buildup toward the west basin (Region 5). A much smaller amount of material moved along the breaker line in Regions 3 and 4 toward the jetties. This usually occurred during the falling tide, when there was no flow in Regions 3 and 4 toward the deposition basin. Also during lower water levels the breaker line was farther oceanward. A small proportion of material moved to the west jetty tips and was entrained with the ebb flow exiting the entrance. This material was then moved across the entrance under the influence of the waves to Region 8. Traces settled in and around the outer portion of Region 6, although most of the material bypassed ultimately deposited in the east basin (Region 12). This movement was

similar for both lengths of jetties. Figure 42 shows the results of test 16 (short jetties) with the material fed from west of the west jetty. Figure 43 shows the results of test 20 (short jetties, Plates 124 and 125) in which a lighter tracer material (plastic, specific gravity = 1.05) was used. Test conditions differed from those of test 16 only in that a 2.5-ft wave was used and the test duration was 18 tidal cycles. The same movement trends were noted for both tests. With littoral material injected from east of the east jetty with the S58°E wave (tests 7 and 10, Plates 98-99 and 104-105), almost all material moved into the east basin and no material moved past the east jetty, whether it extended to the -8 ft contour or the -12 ft contour. Therefore, a shorter jetty did not respond significantly different than the longer jetty with respect to littoral movements to the west. Dye movement tests are shown in Plates 106-109, 114, and 115 for various wave directions. Two tests using the heavy microbead material are described in Plates 90 and 91. Tests using smaller or larger wave heights are described in Plates 94-97, 110-111, and 122-123.

95. The ability of the basins to capture sand was mentioned implicitly in the above discussion. With waves bringing material in from the east, there was immediate movement into the east basin, more so during flood flow when tidal currents were directed at the basin. When waves were bringing material in from the west a fillet would form between Waiter Island and the weir section. Once this was established, almost all material would enter the west deposition basin. Before this, however, some material tended to move in the surf zone toward the west jetty, although this was only a small proportion of the total material fed in during tracer tests. Once the bathymetry readjusts to the jetty system, most material would usually move into the west basin.

96. Sedimentation testing, using a lightweight granular plastic material as a tracer, indicated that the deposition basins of Plans 2D and 2D1 (see Figures 28 and 38) would be efficient at capturing most of the longshore drift entering from either the east or west in the respective basin. In the case of the westerly basin, a fillet likely would build and extend from Waiter Island to the west weir section.

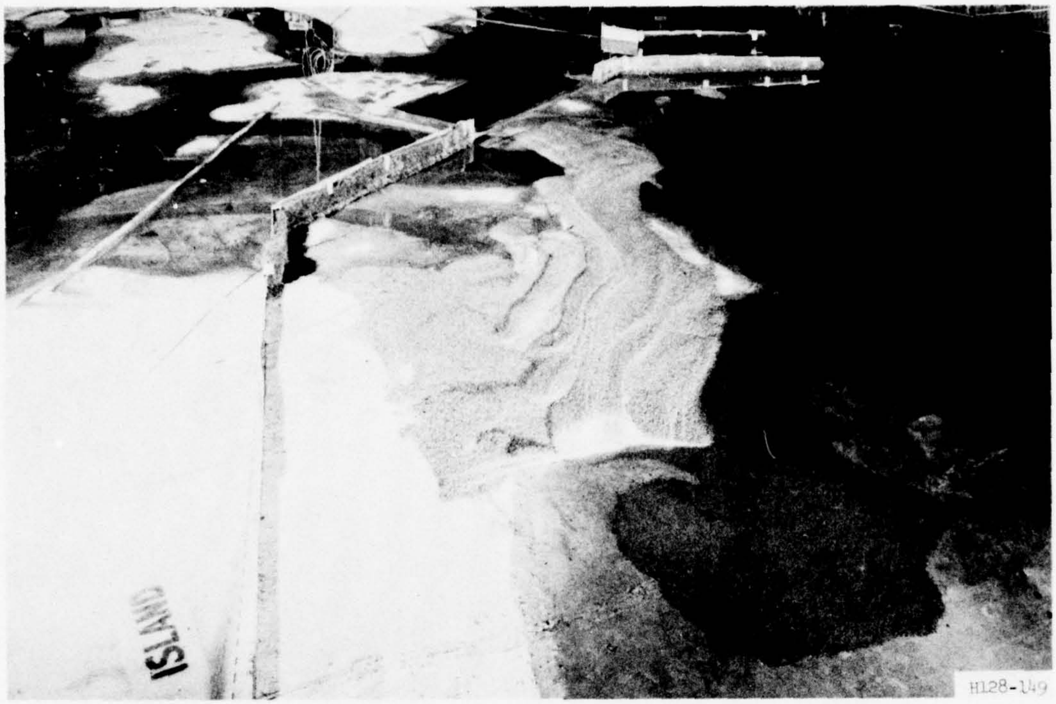




Figure 42. Post test 16 (Littoral Drift Injection Test)

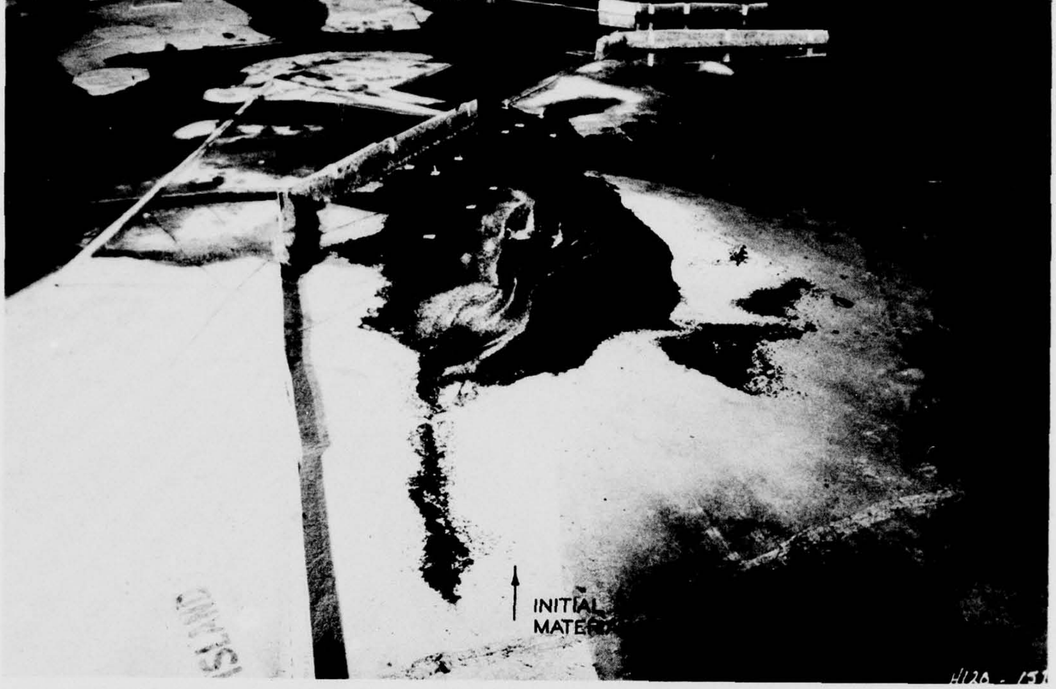




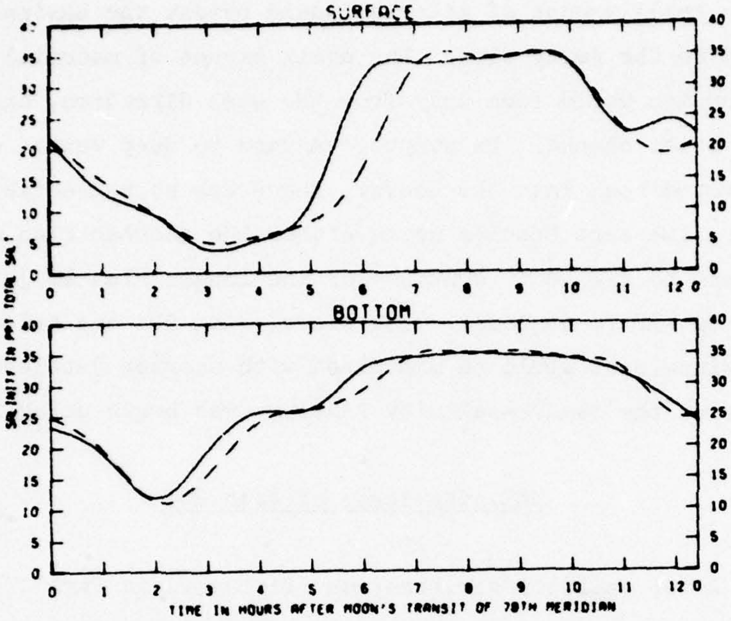
Figure 43. Post Test 20 (Littoral Drift Injection Test)

Only a very small amount of material would bypass the basins and be transported to the jetty tips. The small amount of material that would feed this region would come only from the west direction, and it would bypass the inlet channel, be swept oceanward to deep water, or eventually be moved back into the basin. There was no appreciable difference between the test results using either the shorter Plan 2D1 jetties (which extend to the -8 ft contour) or the longer Plan 2D jetties (which extend to the -12 ft contour). Therefore, Plan 2D1 was selected as the best plan since cost would be minimized with shorter jetties and the final phase of the study--salinity testing--was begun using Plan 2D1.

## Salinity Tests of Plan 2D1

97. After salinity verification (discussed in Part III) Plan 2D1 (Figure 38) was installed in the model, and salinity data were collected at all the verified locations (Ranges 1-7) plus sta 8 and 9. Sta 8 was located in the region of high shellfish concentration in Dunn Sound Creek, and sta 9 was located near Mad Inlet (Figure 20). Base data were taken at sta 8 and 9 simultaneously with the model verification data at ranges 1-7 for the 5.0-ft mean tide and the average freshwater inflow condition of 1200 cfs.

98. Two identical runs were made, and the results were averaged. These data are compared with the base test in Plates 126-142. The most notable salinity changes occurred between the hours of 4 and 7 (rising tide) at Ranges 5, 6, and 7. For example, at sta 6C (Figure 44) the surface salinities show a shift in the time of rise of the salinities as the flood flow begins. The reason for this shift and the trend to a slightly higher freshwater content in the estuary is probably the slight reduction (about 10 percent) in tidal prism caused by restricting the entrance. Natural deepening of the entrance channel after jetty construction probably will increase the tidal prism; thus there will likely be less effect on the salinity distribution than noted in the model tests. Therefore, this test probably shows the extreme change for a mean freshwater flow condition. Ranges 1, 2, 3, and 4



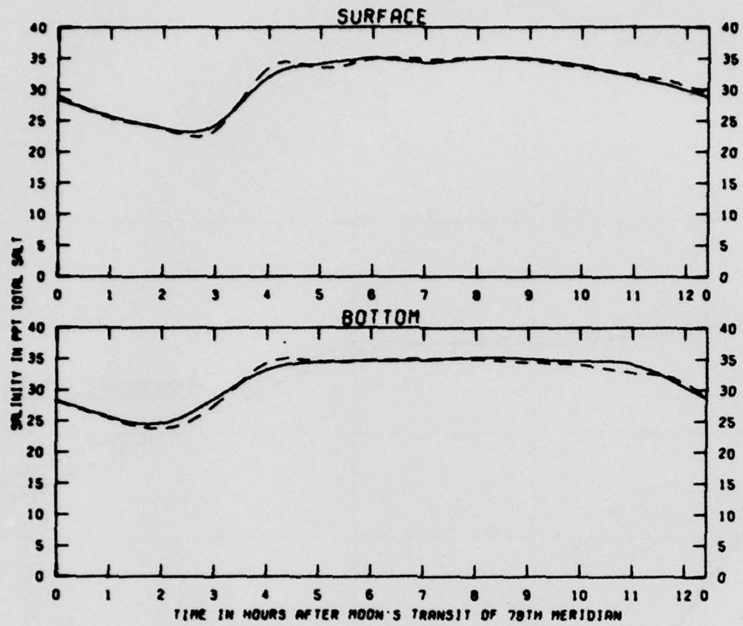

TEST CONDITIONS
OCEAN TIDE RANGE = 5.0 FT

LEGEND
——— BASE
– – – – PLAN 2D1

Figure 44. Effects of Plan 2D1 on salinities at sta 6C

(Plates 126-134) showed only very slight changes (for example, see Figure 45 (sta 3C)). Sta 8A (Plate 142) showed a small reduction (1.8 ppt) in the average salinity. The average salinity at sta 9A (Plate 142) increased slightly (0.6 ppt).

99. Table 9 shows the differences between salinities averaged over a tidal cycle for the base and Plan 2D1. For all stations, the average difference was 0.6 ppt between base and plan average salinities, indicating only slight changes. The average salinity of all stations sampled in the bay for the base was 26.2 ppt and the average for the plan was 26.0 ppt. Although this indicates a slight raising of the freshwater content in the bay with the jetties in place for this mean freshwater inflow condition, the repeatability of the average bay salinity is 0.3 ppt for identical runs. Therefore, the apparent difference




TEST CONDITIONS
OCEAN TIDE RANGE = 5.0 FT

LEGEND
——— BASE
– – – – PLAN 2D1

Figure 45. Effects of Plan 2D1 on salinities at sta 3C

between base and plan average salinities is within the natural variance of the salinities in the model and is insignificant.

100. Figures 46 and 47 show surface and bottom profile plots of the averaged maximum and minimum salinities for Ranges 3-7 (Figure 20) for base and Plan 2D1. Distances between ranges are shown as scaled fractions of the overall distance between Ranges 3 and 7.

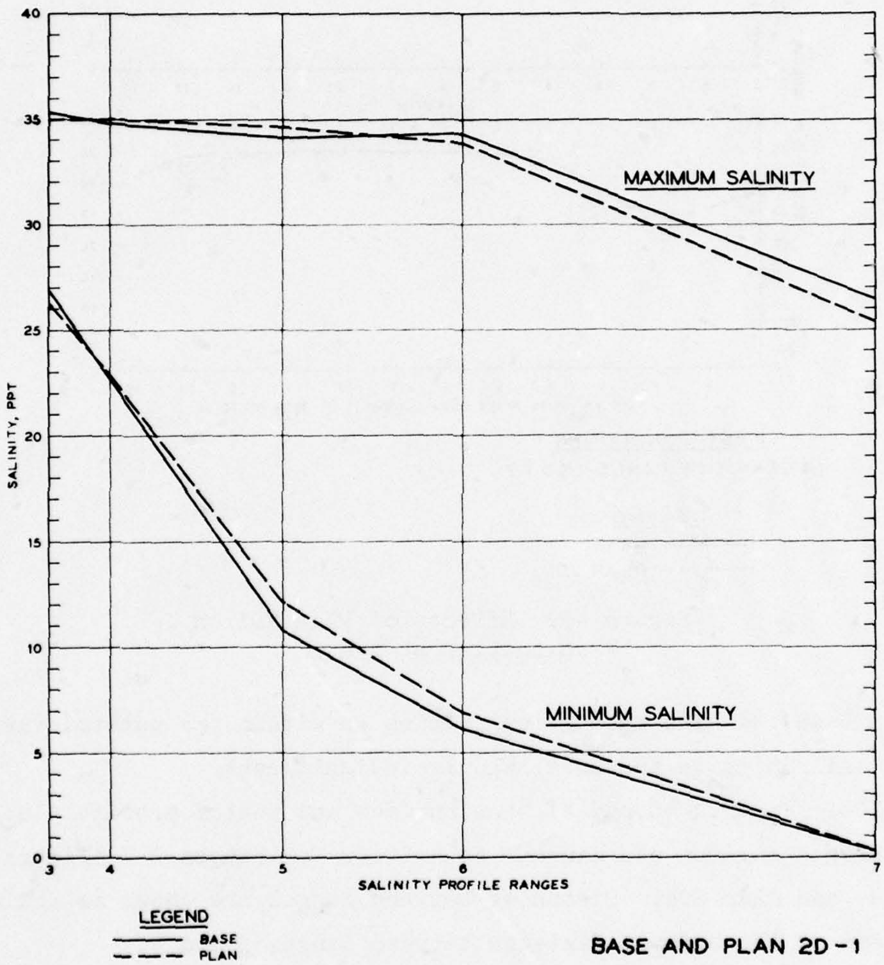



Figure 46. Surface salinity profiles

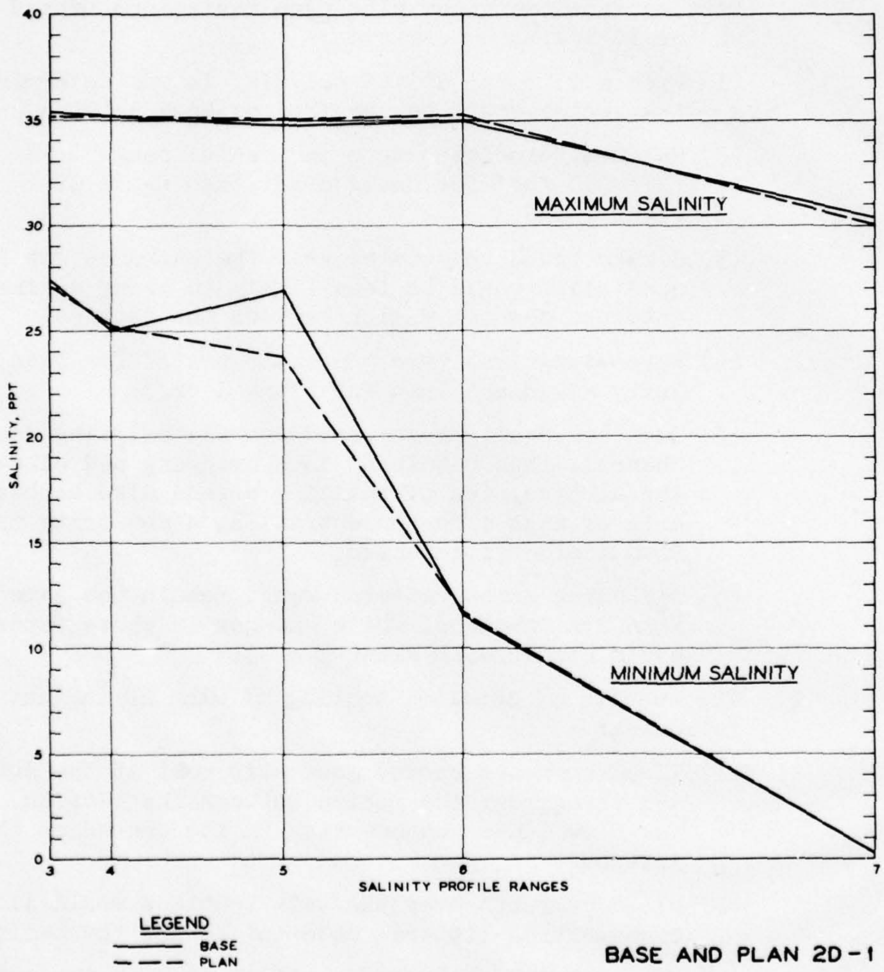



Figure 47. Bottom salinity profiles

## PART V: CONCLUSIONS AND RECOMMENDATIONS

101. Based on the results of the model testing, the following conclusions can be drawn:

a. The Plan 2D jetties orientation was selected for detailed testing from among the nine plan variations tested based on the following information:

(1) From a littoral drift analysis, it was determined that weirs would be required on both jetties.

(2) Maximum velocities were in a safer range (3.2-3.9 fps) for small craft than those of Plans 1 and 3.

(3) Slower flood velocities near the entrance for Plan 2 conditions would be less likely to bring sediments into the channel region between the jetties.

(4) Wave conditions were generally better for Plan 2 jetty alignment than for Plans 1 or 3.

(5) The Plan 2 alignment would use the existing deep ebb channel, thus requiring less dredging and alleviating the difficulties of building a sand dike across this area of high flow concentration, a necessity if Plan 1 or 3 is selected.

(6) Bay circulation patterns would remain the same for Plan 2 alignments, while changes in these patterns would result with Plans 1 or 3.

b. The results of detailed testing of Plan 2D indicated the following:

(1) Flood currents showed good alignment at the entrance and throughout the region between the jetties, with the flow lines concentrated in the center of the jetties.

(2) Flood currents over the weir sections would aid in transporting littoral material toward the basins.

(3) Ebb currents showed good alignment with the jetties and were uniformly distributed across the channel.

(4) Flows between the jetties were ebb-dominant, thus facilitating a net oceanward movement of sediments entering the channel reach between the jetties.

(5) The mean tide level elevation of the weirs was effective in preventing ebb flow over the weirs, since maximum ebb flows usually occurred when the water surface was below this elevation. It is

important to prevent ebb flow over the weirs since such flow may cause scouring through the basin and also reduce the concentration of ebb flow between the jetties, which in turn would reduce the channel scouring by the ebb currents. Also, ebb flow over the weirs would push sand oceanward that had been transported to the weir by littoral currents, probably reducing the quantity of material that could be captured by the basins. Thus it is important that the 0.0 msl weir elevation be carefully maintained, especially if the weir section is of rock rubble-mound construction.

(6) There was no significant change to the tidal prism of the inlet. Bay tides and velocities remained very similar to the existing conditions. There was no major change in bay circulation patterns.

(7) Tracer tests indicated that the location, orientation, and elevation of the weirs and sediment basins for both plans were effective in permitting longshore sediment drift to pass over the weirs into the basin.

(8) The 1000-ft spacing of jetties was adequate to pass the tidal flow without excessively high or undesirably low velocities.

(9) Velocity increases of up to 1.5 fps in ebb and flood flows were noted in Mad Inlet.

c. From testing of the shorter jettied version of Plan 2D, identified as Plan 2D1, the following conclusions were made:

(1) Comparison of Plan 2D versus Plan 2D1 (jetties extending to the -12 ft contour and jetties extending to the -8 ft contour, respectively) showed that there was no difference in the two plans with respect to hydraulic or sedimentation testing.

(2) There was no significant change to the salinity regimen of the bay.

d. Final recommendations:

(1) The shorter Plan 2D1 jetty system should be constructed in order to facilitate cost savings in construction over the Plan 2D system. Shorter jetties should be satisfactory in this project since weirs for trapping longshore drift are located on each jetty and thus the greater fillet forming capability of longer jetties was not needed in this case.

(2) Fill material resulting from dredging the west basin

should be placed to the west of the basin to an elevation greater than high water in order to prevent ebb currents from eroding the sand dike and cutting through the deposition basin.

(3) Armoring of the bay channel side of the basins region would be desirable. Also, it would be desirable to armor the region behind the east basin near range 3A in order to prevent erosion of this protective arm of sand, which if eroded might permit ebb currents to cut through the east deposition basin. If ebb currents are permitted to flow through the basins, sediment will be carried to the dredged channel between the jetties, thus defeating the system's design.

102. In conclusion, the Plan 2D1 jetty system should be constructed, which consists of two rubble-mound jetties extending oceanward to the -8 ft contour which meet weir sections of elevation 2.3 mlw on each side of the 12- × 300-ft entrance channel. Sand dikes then connect the system to the east and west shoreline.

## REFERENCES


1. U. S. Army Engineer District, Charleston, "Little River Inlet, Brunswick County, North Carolina, and Harry County, South Carolina, Survey Report on Navigation," May 1971, Charleston, S. C.

2. Simmons, H. B. et al., Estuary and Coastline Hydrodynamics, A. T. Ippen, ed., Massachusetts Institute of Technology, Cambridge, Mass., Chapter 16, pp 673-690, 1966.

3. Dean, R. G., "Coastal Inlet Mechanics and Design Course," Class Notes, May 1971, Coastal Engineering Research Center, Fort Belvoir, Va.

4. O'Brien, M. P. and Dean, R. G., "Hydraulics and Sedimentary Stability of Coastal Inlets," Proceedings, Thirteenth Coastal Engineering Conference, American Society of Civil Engineers, New York, Jul 1972, pp 761-780.

5. Jarrett, J. T., "Analysis of the Hydraulics Characteristics of Tidal Inlets" (unpublished memorandum), 28 Apr 1975, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

6. U. S. Army Engineer District, Charleston, "Little River Inlet, North Carolina and South Carolina, Navigation Project, General Design Memorandum," Design Memorandum No. 1, Sep 1976, Charleston, S. C.

7. Kieslich, J. M. and Mason, C., "Channel Entrance Response to Jetty Construction," Civil Engineering in the Oceans, Third Conference, Newark, Del., 1975, Vol I, pp 689-705.

8. Sager, R. A, and Seabergh, W. C., "Physical Model Simulation of the Hydraulics of Masonboro Inlet, North Carolina" (in preparation), U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss., and U. S. Army Coastal Engineering Research Center, Fort Belvoir, Va.

9. O'Brien, M. P., "Equilibrium Flow Areas of Inlets on Sandy Coast," Journal, Waterways, Harbors, and Coastal Engineering Division, American Society of Civil Engineers, Vol 95, No. WW1, Feb 1969, pp 43-52.

10. Jarrett, J. T., "Tidal Prism--Inlet Area Relationships," GITI Report 3, Feb 1976, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss., and U. S. Army Coastal Engineering Research Center, Fort Belvoir, Va.

11. Kamphuis, J. W., "Coastal Mobile Bed Model--Does It Work?," Sumposium on Modeling Techniques; Vol II, Harbors and Coastal Engineering Division, American Society of Civil Engineers, San Francisco, Calif., Sep 1975, pp 993-1009.

12. Yalin, M. S., Theory of Hydraulic Models, Macmillan Press, New York, 1971.

Table 1

Average Salinity for Complete Cycle, Prototype Versus Model

| Range and Station | Surface Salinity, ppt | | | Middepth Salinity, ppt | | | Bottom Salinity, ppt | | |
|---|---|---|---|---|---|---|---|---|---|
| | Prototype | Model | Difference | Prototype | Model | Difference | Prototype | Model | Difference |
| 1-A | 19.5 | 18.9 | -0.6 | | | | 24.4 | 27.8 | +3.4 |
| 1-B | 23.0 | 18.4 | -4.6 | | | | 25.0 | 29.1 | +4.1 |
| 2-A | | | | 27.4 | 29.5 | +2.1 | | | |
| 2-B | 25.7 | 26.5 | +0.8 | | | | 27.2 | 31.0 | +3.8 |
| 3-A | 29.9 | 32.7 | +2.8 | | | | 30.6 | 33.2 | +2.6 |
| 3-B | 29.2 | 32.5 | +3.3 | | | | 29.2 | 33.0 | +3.8 |
| 3-C | 29.2 | 30.8 | +1.6 | | | | 29.7 | 31.6 | +1.9 |
| 4-A | 29.0 | 30.8 | +1.8 | | | | 29.2 | 31.6 | +2.4 |
| 4-B | 28.5 | 29.9 | +1.4 | | | | 28.7 | 31.7 | +3.0 |
| 4-C | 28.1 | 30.0 | +1.9 | | | | 28.1 | 31.2 | +3.1 |
| 5-A | | | | 24.2 | 25.3 | +1.1 | | | |
| 5-B | 23.6 | 23.9 | +0.3 | | | | 28.0 | 31.4 | +3.4 |
| 5-C | | | | 24.3 | 25.0 | +0.7 | | | |
| 6-A | 18.1 | 19.0 | +0.9 | | | | 26.2 | 28.3 | +2.1 |
| 6-B | 19.0 | 21.5 | +2.5 | | | | 23.9 | 28.1 | +4.2 |
| 6-C | 19.0 | 21.3 | +2.3 | | | | 22.2 | 27.1 | +4.9 |
| 7-A | 10.4 | 10.2 | -0.2 | | | | 13.7 | 12.2 | -1.5 |
| 7-B | 8.1 | 8.5 | +0.4 | | | | 11.2 | 13.4 | +2.2 |

Average Difference at Surface = 1.7

Average Difference at Middepth = 1.3

Average Difference at Bottom = 3.1

Table 2

Maximum Surface Currents by Region*

| | Velocity, fps | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | |
| Plan | Ebb | Flood | Ebb | Flood | Ebb | Flood | Ebb | Flood | Ebb | Flood | Ebb | Flood | Ebb | Flood | Ebb | Flood |
| 1-A | 4.1 | 3.5 | 5.0 | 4.5 | 1.3 | 1.6 | 3.1 | 1.1 | 2.2 | 3.2 | 0.5 | 2.2 | 1.6 | 2.0 | 1.2 | 1.0 |
| 1-B | 4.2 | 4.0 | 5.3 | 4.3 | 1.6 | 2.2 | 2.6 | 2.2 | 2.2 | 2.7 | 0.8 | 3.0 | 1.5 | 2.2 | 1.3 | 1.1 |
| 1-C | 4.7 | 3.0 | 5.0 | 5.0 | 2.3 | 2.5 | 3.6 | 2.4 | 2.2 | 2.2 | 0.8 | 2.5 | 1.4 | 2.0 | 1.4 | 1.0 |
| 1-D | 4.8 | 3.8 | 5.2 | 4.5 | 2.2 | 2.6 | 2.3 | 2.3 | 2.3 | 2.2 | 0.9 | 2.5 | 1.6 | 2.2 | 1.5 | 1.0 |
| 2-A | 4.0 | 3.3 | 4.3 | 4.2 | 3.7 | 1.3 | 1.2 | 1.2 | 2.2 | 2.0 | 2.5 | 1.6 | 2.5 | 1.8 | 3.9 | 4.1 |
| 2-B | 3.5 | 3.1 | 4.0 | 3.6 | 2.9 | 2.4 | 2.4 | 1.8 | 2.2 | 2.1 | 2.1 | 3.0 | 2.3 | 1.2 | 3.4 | 3.3 |
| 2-C | 3.5 | 2.6 | 4.1 | 2.8 | 3.5 | 2.0 | 1.3 | 1.2 | 2.0 | 1.9 | 2.0 | 3.3 | 2.4 | 1.5 | 3.3 | 3.6 |
| 2-D | 3.2 | 2.7 | 3.9 | 2.7 | 3.2 | 2.9 | 1.5 | 1.3 | 2.0 | 2.2 | 2.0 | 3.2 | 2.2 | 1.5 | 3.0 | 3.5 |
| 3 | 3.3 | 3.1 | 4.8 | 4.5 | 3.2 | 2.0 | 3.5 | 3.7 | 2.0 | 2.4 | 0.9 | 2.5 | 2.1 | 2.8 | 0.5 | 0.5 |

* See index in Plate 39.

Table 3

Wave Heights at Gages 7-11

Wave Direction from South, 7-sec Period, 4.6-ft Wave Height

| Gage | Flow Condition | Wave Height, ft, Plan 1A | 1B | 1C | 1D | 2A | 2B | 2C | 2D | 3 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Max flood | 6.1 | 5.5 | 7.7 | 6.0 | 2.0 | 2.3 | 2.9 | 2.7 | 4.4 |
| | High slack | 6.8 | 6.2 | 8.9 | 5.2 | 2.6 | 2.9 | 2.5 | 3.5 | 4.8 |
| | Max ebb | 10.4 | 9.9 | 7.7 | 8.4 | 3.6 | 6.0 | 6.7 | 7.1 | 9.3 |
| | Low slack | 7.4 | 9.1 | 7.2 | 8.1 | 2.4 | 4.0 | 5.3 | 2.9 | 8.6 |
| | Avg | 7.7 | 7.7 | 7.9 | 6.9 | 2.7 | 3.8 | 4.4 | 4.1 | 6.8 |
| 8 | Max flood | 1.9 | 1.9 | 2.1 | 1.5 | 1.0 | 1.2 | 1.3 | 1.3 | 1.6 |
| | High slack | 2.1 | 1.9 | 2.7 | 1.3 | 1.0 | 2.1 | 1.3 | 1.6 | 1.7 |
| | Max ebb | 4.4 | 4.5 | 4.6 | 3.7 | 1.6 | 2.3 | 3.2 | 3.2 | 3.3 |
| | Low slack | 2.3 | 3.6 | 2.8 | 2.8 | 1.2 | 2.4 | 3.6 | 2.1 | 3.2 |
| | Avg | 2.7 | 3.0 | 3.1 | 2.3 | 1.2 | 2.0 | 2.4 | 2.1 | 2.5 |
| 9 | Max flood | 0.1 | 0.3 | 0.9 | 0.8 | 0.1 | 0.8 | 0.7 | 1.1 | 0.1 |
| | High slack | 0.2 | 0.2 | 1.6 | 1.3 | 0.3 | 1.6 | 1.1 | 1.7 | 0.1 |
| | Max ebb | 0.1 | 0.2 | 0.2 | 0.1 | 0.3 | 0.7 | 0.7 | 0.9 | 0.2 |
| | Low slack | 0.2 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.9 | 0.6 | 0.2 |
| | Avg | 0.2 | 0.3 | 0.9 | 0.7 | 0.4 | 1.0 | 0.9 | 1.1 | 0.2 |
| 10 | Max flood | 0.9 | 0.9 | 2.3 | 1.9 | 0.7 | 1.2 | 1.9 | 2.0 | -- |
| | High slack | 1.0 | 0.2 | 2.5 | 2.0 | 0.7 | 1.3 | 2.0 | 2.2 | -- |
| | Max ebb | 0.1 | 0.0 | 0.0 | 0.0 | 0.2 | 0.7 | 0.7 | 0.8 | -- |
| | Low slack | 0.1 | 0.0 | 0.0 | 0.0 | 0.5 | 1.1 | 1.2 | 0.5 | -- |
| | Avg | 0.5 | 0.3 | 1.2 | 1.0 | 0.5 | 1.1 | 1.5 | 1.4 | -- |
| 11 | Max flood | 1.9 | 1.6 | 2.2 | 1.9 | 0.9 | 2.6 | 1.3 | 2.9 | -- |
| | High slack | 1.3 | 2.6 | 1.5 | 1.3 | 1.2 | 2.8 | 1.1 | 2.8 | -- |
| | Max ebb | 0.1 | 0.0 | 0.0 | 0.0 | 0.2 | 0.7 | 1.1 | 1.0 | -- |
| | Low slack | 0.1 | 0.0 | 0.0 | 0.0 | 0.7 | 1.2 | 1.7 | 1.2 | -- |
| | Avg | 0.9 | 1.1 | 0.9 | 0.8 | 0.8 | 1.8 | 1.3 | 2.0 | -- |

Table 4

Wave Heights at Gages 7-11

Wave Direction from S58°E, 7-sec Period, 4.8-ft Height

| Gage | Flow Condition | Wave Height, ft, Plan 1A | 1B | 1C | 1D | 2A | 2B | 2C | 2D | 3 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Max flood | 3.1 | 3.4 | 5.0 | 2.9 | 5.1 | 5.4 | 5.7 | 6.3 | 3.8 |
| | High slack | 4.1 | 4.0 | 6.2 | 3.0 | 6.1 | 5.2 | 5.7 | 6.0 | 4.7 |
| | Max ebb | 4.0 | 4.4 | 6.5 | 4.6 | 5.6 | 5.0 | 4.8 | 5.7 | 4.2 |
| | Low slack | 4.4 | 4.6 | 5.0 | 5.1 | 5.6 | 5.4 | 5.1 | 5.7 | 3.7 |
| | Avg | 3.9 | 4.1 | 5.7 | 3.9 | 5.6 | 5.3 | 5.3 | 5.9 | 4.1 |
| 8 | Max flood | 1.4 | 1.4 | 1.4 | 1.2 | 1.3 | 1.5 | 1.5 | 1.9 | 1.3 |
| | High slack | 1.2 | 1.2 | 1.5 | 1.4 | 1.3 | 1.5 | 1.4 | 1.3 | 1.3 |
| | Max ebb | 2.4 | 2.0 | 1.6 | 2.7 | 1.6 | 1.4 | 1.4 | 1.4 | 1.6 |
| | Low slack | 1.3 | 1.2 | 1.5 | 1.7 | 1.7 | 1.8 | 2.0 | 1.9 | 1.6 |
| | Avg | 1.6 | 1.5 | 1.5 | 1.8 | 1.5 | 1.6 | 1.6 | 1.6 | 1.5 |
| 9 | Max flood | 0.2 | 0.2 | 0.0 | 0.2 | 0.7 | 1.5 | 1.0 | 1.9 | 0.0 |
| | High slack | 0.2 | 0.2 | 0.1 | 0.1 | 0.6 | 1.9 | 0.9 | 2.2 | 0.1 |
| | Max ebb | 0.2 | 0.2 | 0.0 | 0.1 | 0.3 | 0.2 | 0.3 | 0.1 | 0.1 |
| | Low slack | 0.3 | 0.2 | 0.2 | 0.2 | 0.7 | 0.8 | 0.6 | 0.2 | 0.1 |
| | Avg | 0.2 | 0.2 | 0.1 | 0.2 | 0.6 | 1.1 | 0.7 | 1.1 | 0.1 |
| 10 | Max flood | 1.1 | 0.9 | 1.0 | 0.9 | 1.2 | 1.2 | 1.6 | 1.6 | -- |
| | High slack | 0.4 | 1.2 | 1.5 | 1.5 | 1.3 | 1.1 | 1.7 | 2.0 | -- |
| | Max ebb | 0.1 | 0.1 | 0.0 | 0.0 | 0.2 | 0.1 | 0.3 | 0.1 | -- |
| | Low slack | 0.1 | 0.0 | 0.0 | 0.0 | 1.1 | 0.6 | 0.7 | 0.8 | -- |
| | Avg | 0.4 | 0.6 | 0.6 | 0.6 | 1.0 | 0.8 | 1.1 | 1.1 | -- |
| 11 | Max flood | 1.0 | 1.4 | 1.2 | 1.5 | 0.9 | 3.1 | 1.3 | 3.7 | -- |
| | High slack | 0.4 | 2.4 | 1.1 | 2.3 | 1.6 | 3.5 | 1.7 | 3.2 | -- |
| | Max ebb | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.3 | 0.1 | -- |
| | Low slack | 0.1 | 0.0 | 0.0 | 0.0 | 0.9 | 1.3 | 0.7 | 1.0 | -- |
| | Avg | 0.4 | 1.0 | 0.6 | 1.0 | 0.9 | 2.0 | 1.0 | 2.0 | -- |

Table 5

Advantages and Disadvantages of the Plans Tested

| Plan | Positive Aspects | Negative Aspects |
|---|---|---|
| 1A, 1B, 1C, 1D | Good alignment with major ebb currents in interior channel | Higher ebb velocity between jetties--jetties possibly spaced too close |
| | Lower velocities in region of west deposition basin and sand dike than Plan 2 | Higher waves at entrance |
| | Good flood current flow patterns at entrance | High ebb velocities along east weir and sand dike |
| | Good flood flow patterns over weir sections | |
| | Good flood-ebb flow asymmetry over weir sections | |
| 2A, 2B, 2C, 2D | Moderate but adequate velocities between jetties | Higher wave activity in deposition basins than Plan 1 |
| | Low velocities in region of east deposition basin and sand dike | High ebb velocities along west weir and sand dike |
| | Follows the existing natural channel (at inlet's gorge) | High ebb velocities at surface current location 8 |
| | Lower wave heights at entrance on the average than Plans 1 and 3 | High flood velocities at surface current location 6 |
| | Good flood-ebb flow asymetry over weir sections | |
| | Flood flow follows interior channel | |
| 3 | Good alignment with major ebb currents in interior channel | Longer rubble-mound jetties than Plans 1 and 2 |
| | Jetty system farther inland--sand dikes better protected from ocean waves | Higher wave heights at entrance than Plan 2 |

Table 6

Tide Differences Between Base Test and Plan 2D

| Bay Gage* | Phase Shift Rising Tide min | Phase Shift Falling Tide min | High-Water Difference ft | Low-Water Difference ft | Tide Range Difference ft |
|---|---|---|---|---|---|
| 2 | -15 | -10 | 0.0 | -0.2 | 0.2 |
| 3 | -10 | -15 | 0.0 | 0.1 | -0.1 |
| 4 | -15 | -25 | -0.1 | 0.1 | -0.2 |
| 5 | -15 | -20 | 0.0 | 0.0 | 0.0 |
| 6 | -15 | -20 | -0.2 | 0.0 | -0.2 |
| 7 | -10 | -15 | 0.0 | 0.1 | -0.1 |
| 8 | -10 | -5 | -0.1 | -0.2 | 0.1 |
| 9 | -5 | -15 | 0.0 | 0.2 | -0.2 |
| 10 | -5 | -5 | -0.1 | 0.0 | -0.1 |
| 11 | -5 | -15 | 0.0 | -0.2 | -0.2 |
| 13 | -10 | -10 | -0.1 | -0.1 | 0.0 |
| Average | -10 | -14 | -0.1 | 0.0 | -0.1 |

* See Figures 10 and 20 for locations.

Table 7

Average Tidal Elevations, ft, msl

| Gage | Base | Plan 2D | Plan 2D-1 |
|---|---|---|---|
| 2 | 0.38 | 0.32 | 0.25 |
| 3 | 0.11 | 0.18 | 0.18 |
| 4 | 0.16 | 0.20 | 0.11 |
| 5 | 0.09 | 0.13 | 0.18 |
| 6 | 0.14 | 0.11 | 0.10 |
| 7 | 0.11 | 0.15 | 0.15 |
| 8 | 0.26 | 0.18 | 0.18 |
| 9 | 0.09 | 0.17 | 0.11 |
| 10 | -0.06 | -0.06 | -0.03 |
| 11 | 0.08 | 0.19 | 0.11 |
| 13 | 0.07 | 0.02 | 0.10 |
| Avg | +0.13 | +0.14 | +0.13 |

Table 8

Maximum Velocities Along Channel Center Line, fps

| | Ebb Flow | | Flood Flow | |
|---|---|---|---|---|
| Station | Surface | Bottom | Surface | Bottom |
| 8A | 2.2 | 1.2 | 0.4 | 0.1 |
| 9A | 3.4 | 1.7 | 0.6 | 0.4 |
| 10A | 3.9 | 1.6 | 1.1 | 1.2 |
| 11A | 3.0 | 2.2 | 1.9 | 1.6 |
| 12A | 3.4 | 2.5 | 2.5 | 2.0 |
| 15A | 4.0 | 3.0 | 2.3 | 2.1 |

Table 9

Average Salinity Base Versus Plan D1 for Complete Cycle

| Range and Station | Surface Salinity, ppt | | | Middepth Salinity, ppt | | | Bottom Salinity, ppt | | |
|---|---|---|---|---|---|---|---|---|---|
| | Base | Plan 2D1 | Difference | Base | Plan 2D1 | Difference | Base | Plan 2D1 | Difference |
| 1-A | 18.9 | 17.7 | -1.2 | | | | 27.8 | 28.0 | +0.2 |
| 1-B | 18.5 | 17.6 | -0.9 | | | | 29.1 | 29.7 | +0.6 |
| 2-A | | | | 29.5 | 29.6 | +0.1 | | | |
| 2-B | 26.5 | 26.9 | +0.4 | | | | 31.0 | 29.5 | -1.5 |
| 3-A | 32.7 | 32.4 | -0.3 | | | | 33.2 | 32.9 | -0.3 |
| 3-B | 32.5 | 32.3 | -0.2 | | | | 33.0 | 32.7 | -0.3 |
| 3-C | 30.8 | 31.0 | +0.2 | | | | 31.6 | 31.4 | -0.2 |
| 4-A | 30.8 | 30.9 | +0.1 | | | | 31.6 | 31.7 | +0.1 |
| 4-B | 29.9 | 31.2 | +1.3 | | | | 31.7 | 32.1 | +0.4 |
| 4-C | 30.0 | 30.6 | +0.6 | | | | 31.2 | 31.6 | +0.4 |
| 5-A | | | | 25.3 | 24.4 | -0.9 | | | |
| 5-B | 23.9 | 23.9 | 0.0 | | | | 31.4 | 31.2 | -0.2 |
| 5-C | | | | 25.0 | 25.2 | +0.2 | | | |
| 6-A | 19.0 | 17.5 | -1.5 | | | | 28.3 | 28.7 | +0.4 |
| 6-B | 21.5 | 20.9 | -0.6 | | | | 28.1 | 27.4 | -0.7 |
| 6-C | 21.3 | 20.1 | -1.2 | | | | 27.1 | 26.9 | -0.2 |
| 7-A | 10.2 | 10.0 | -0.2 | | | | 12.2 | 12.3 | +0.1 |
| 7-B | 8.5 | 9.5 | +1.0 | | | | 13.4 | 13.4 | 0.0 |
| 8-A | | | | 28.7 | 26.9 | -1.8 | | | |
| 9-A | | | | 31.7 | 32.3 | +0.6 | | | |
| | Average Difference at Surface = 0.6 | | | Average Difference at Middepth = 0.7 | | | Average Difference at Bottom = 0.4 | | |


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
BASE TEST

HOUR 0

PHOTO 1


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS

BASE TEST

HOUR 1

PHOTO 2

AD-A049 639 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 8/3
IMPROVEMENTS FOR LITTLE RIVER INLET SOUTH CAROLINA. HYDRAULIC M--ETC(U)
NOV 77 W C SEABERGH, E F LANE
UNCLASSIFIED WES-TR-H-77-21 NL

2 OF 4
ADA049 639

4

639


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SUR

19


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
BASE TEST

HOUR 3

PHOTO 4


SURFACE CURRENTS

1974 CONDITIONS
BASE TEST

HOUR 4

PHOTO 5


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS

BASE TEST

HOUR 5

PHOTO 6


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

# SURFACE CURRENTS

## 1974 CONDITIONS
## BASE TEST

HOUR 6

PHOTO 7


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
BASE TEST

HOUR 7

PHOTO 8


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
BASE TEST

HOUR 8

PHOTO 9


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS

BASE TEST

HOUR 9

PHOTO 10


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS

BASE TEST

HOUR 10

PHOTO 11


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
BASE TEST

HOUR 11

PHOTO 12


VELOCITY SCALE

0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

**EBB FLOW**

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
BASE TEST

HOUR 12

PHOTO 13

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-A

EBB FLOW HOUR 0

PHOTO 14

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

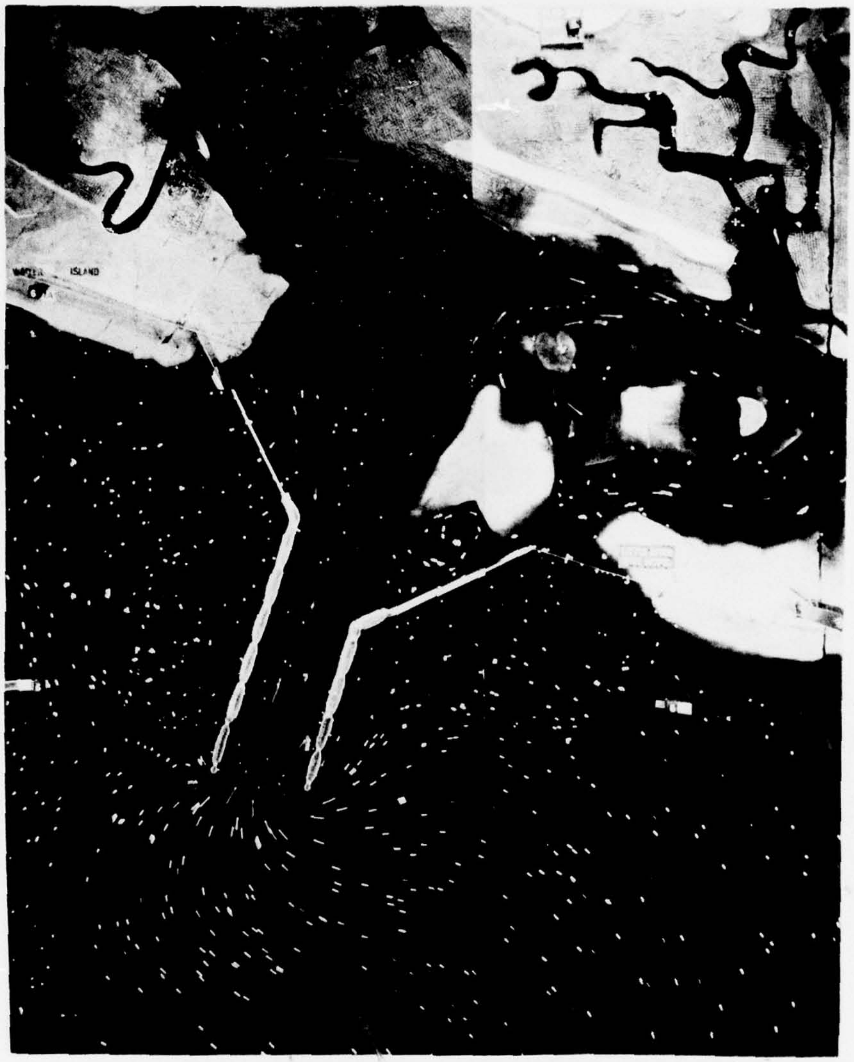
MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN I-A

FLOOD FLOW HOUR 4

PHOTO 15




VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-A

FLOOD FLOW HOUR 6

PHOTO 16

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN I-A

EBB FLOW HOUR 9

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

## SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-B

EBB FLOW HOUR 0

PHOTO 18

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS
1974 CONDITIONS
WITH PLAN 1-B
FLOOD FLOW HOUR 4

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-B

FLOOD FLOW HOUR 6

PHOTO 20

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-B

EBB FLOW HOUR 9

PHOTO 21

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-C

EBB FLOW HOUR 0

PHOTO 22


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-C

FLOOD FLOW HOUR 4

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN I-C

FLOOD FLOW HOUR 6

PHOTO 24

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-C

EBB FLOW HOUR 9

PHOTO 25

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-D

EBB FLOW HOUR 0

PHOTO 26

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 1-D

FLOOD FLOW HOUR 4

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN I-D

FLOOD FLOW HOUR 6

PHOTO 28

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN I-D

EBB FLOW HOUR 9


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS WITH PLAN 2-A

EBB FLOW HOUR 0

PHOTO 30


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

# SURFACE CURRENTS
## 1974 CONDITIONS WITH PLAN 2-A
FLOOD FLOW HOUR 4

PHOTO 31


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-A

FLOOD FLOW HOUR 6

PHOTO 32

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-A

EBB FLOW HOUR 9


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-B

EBB FLOW HOUR 0

PHOTO 34


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-B

FLOOD FLOW HOUR 4

PHOTO 35


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-B

FLOOD FLOW HOUR 6

PHOTO 36


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-B

EBB FLOW HOUR 9


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-C

EBB FLOW HOUR 0

PHOTO 38


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-C

FLOOD FLOW HOUR 4

1 0 1 2 3 4 5 6 7 8
FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-C

FLOOD FLOW HOUR 6

PHOTO 40


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-C

EBB FLOW HOUR 9

PHOTO 41


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

## SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-D

EBB FLOW HOUR 0

PHOTO 42


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-D

FLOOD FLOW HOUR 4


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

## SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-D

FLOOD FLOW HOUR 6


VELOCITY SCALE
1 0 1 2 3 4 5 6 7 8
FPS, PROTOTYPE

SCALES IN FEET
PROTOTYPE 300 0 300 600 900 1200 1500 1800
MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS
1974 CONDITIONS
WITH PLAN 2-D
EBB FLOW HOUR 9

PHOTO 45


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 3

EBB FLOW HOUR 0

PHOTO 46


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 3

FLOOD FLOW HOUR 4


VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 3

FLOOD FLOW HOUR 6

PHOTO 48

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

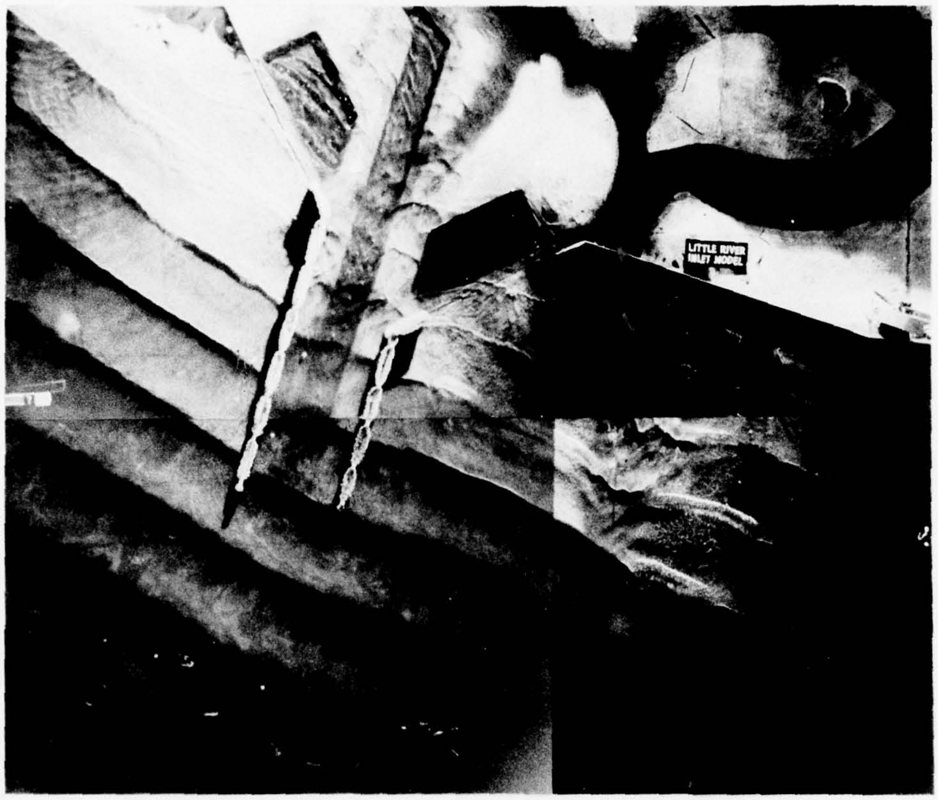
MODEL 1 0 1 2 3 4 5 6

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 3

EBB FLOW HOUR 9

PHOTO 49




CONDITIONS

OCEAN WAVE HEIGHT = 460 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = 242 FEET MSL

SCALES IN FEET

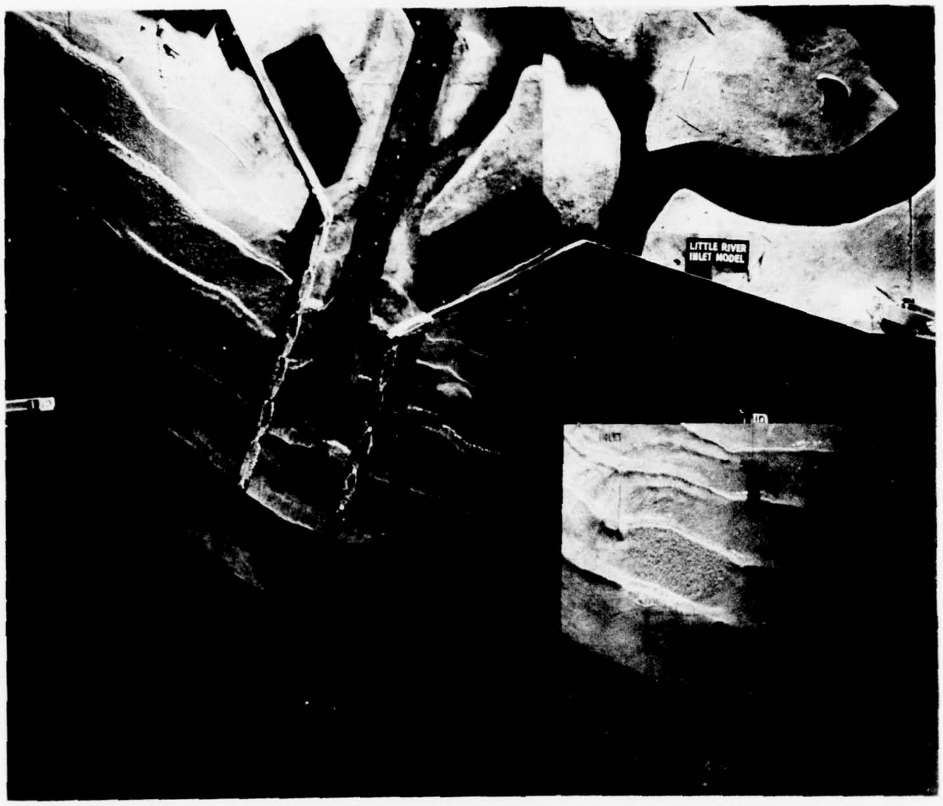
PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 1-D

SOUTH WAVES AT HIGH WATER

PHOTO 50




CONDITIONS

OCEAN WAVE HEIGHT = 460 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = -255 FEET MSL

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 1-D

SOUTH WAVES AT LOW WATER


CONDITIONS

OCEAN WAVE HEIGHT = 4.80 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = 242 FEET MSL

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 1-D

S 58° E WAVES AT HIGH WATER

PHOTO 52


CONDITIONS

OCEAN WAVE HEIGHT = 4.80 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = -2.55 FEET MSL

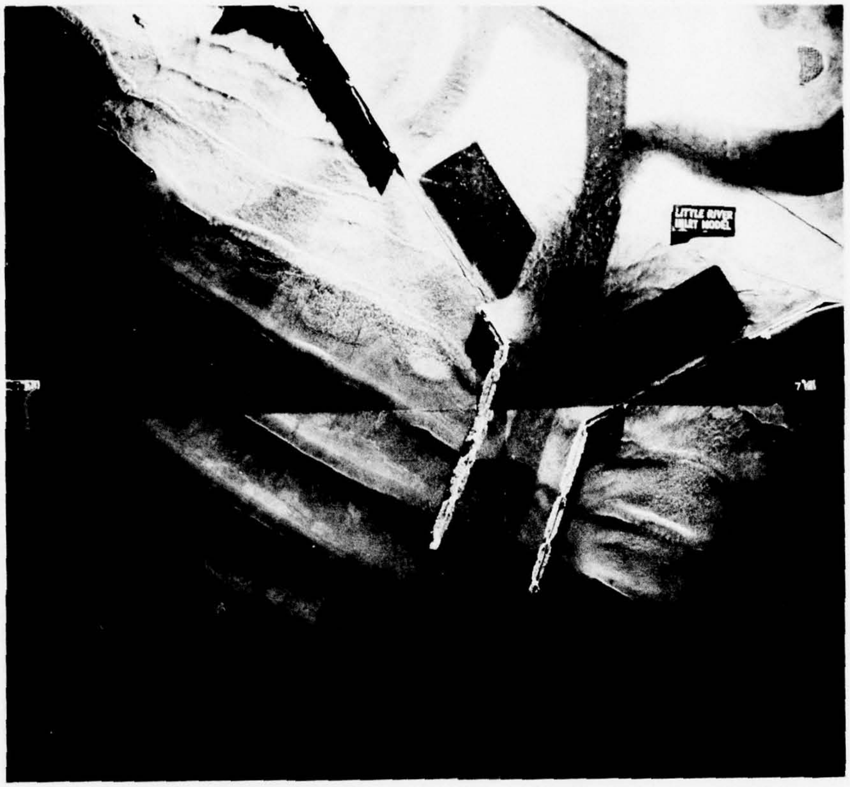
SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 1-D

S 58° E WAVES AT LOW WATER




CONDITIONS

OCEAN WAVE HEIGHT = 460 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = 242 FEET MSL

SCALES IN FEET

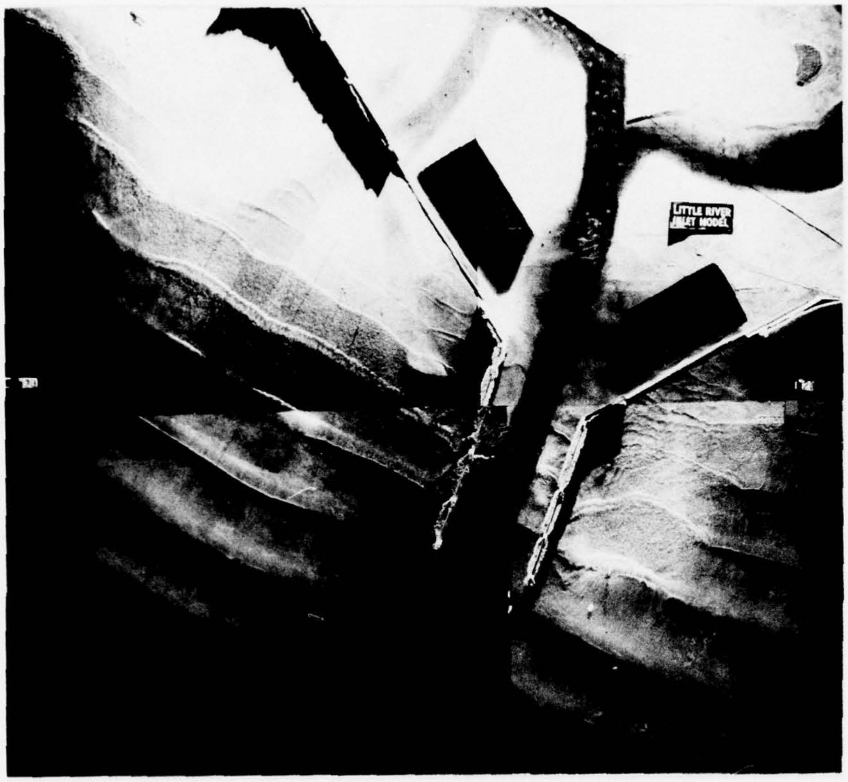
PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 2-D

SOUTH WAVES AT HIGH WATER

PHOTO 54




CONDITIONS

OCEAN WAVE HEIGHT = 4.60 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = -2.55 FEET MSL

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 2-D

SOUTH WAVES AT LOW WATER


CONDITIONS

OCEAN WAVE HEIGHT = 4.80 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = 2.42 FEET MSL

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 2-D

S 58° E WAVES AT HIGH WATER

PHOTO 56


CONDITIONS

OCEAN WAVE HEIGHT ≈ 4.80 FEET
OCEAN WAVE PERIOD ≈ 7 SECONDS
OCEAN TIDE LEVEL ≈ -2.55 FEET MSL

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 2-D

S 58° E WAVES AT LOW WATER

PHOTO 57


CONDITIONS

OCEAN WAVE HEIGHT = 4.60 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = 2.42 FEET MSL

SCALES IN FEET

| | |
|---|---|
| PROTOTYPE | 300 0 300 600 900 1200 1500 1800 |
| MODEL | 1 0 1 2 3 4 5 6 |

PLAN 3

SOUTH WAVES AT HIGH WATER


CONDITIONS

OCEAN WAVE HEIGHT = 4.60 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = -2.55 FEET MSL

SCALES IN FEET

| | |
|---|---|
| | 300 0 300 600 900 1200 1500 1800 |
| PROTOTYPE | |
| | 1 0 1 2 3 4 5 6 |
| MODEL | |

PLAN 3

SOUTH WAVES AT LOW WATER


CONDITIONS

OCEAN WAVE HEIGHT = 4.80 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = 242 FEET MSL

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 3

S 58° E WAVES AT HIGH WATER

PHOTO 60


CONDITIONS

OCEAN WAVE HEIGHT = 4.80 FEET
OCEAN WAVE PERIOD = 7 SECONDS
OCEAN TIDE LEVEL = -2.55 FEET MSL

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL 1 0 1 2 3 4 5 6

PLAN 3

S 58° E WAVES AT LOW WATER

NOTE: JETTIES EXTENDED TO -8 FT CONTOUR

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

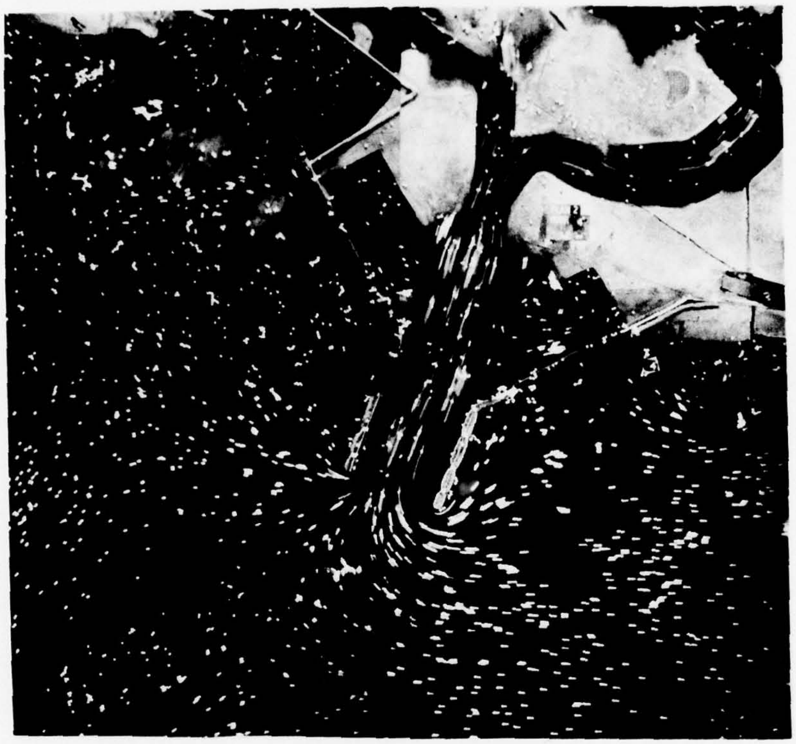
MODEL

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-D1

EBB FLOW HOUR 0

PHOTO 62



NOTE: JETTIES EXTENDED TO
-8 FT CONTOUR

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

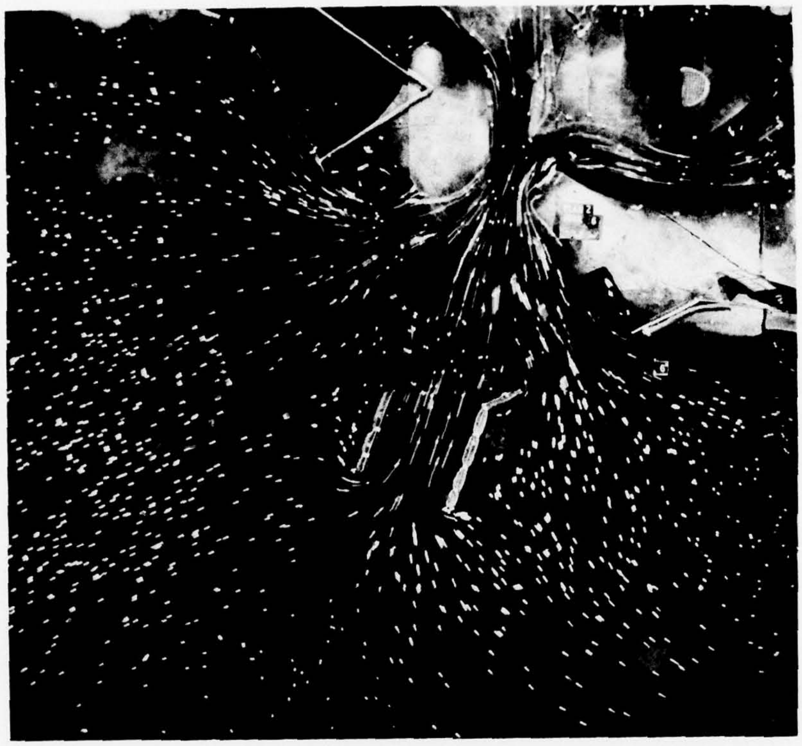
SCALES IN FEET

| | |
|---|---|
| | 300 0 300 600 900 1200 1500 1800 |
| PROTOTYPE | |
| MODEL | |

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-D1

FLOOD FLOW HOUR 4



NOTE: JETTIES EXTENDED TO -8 FT CONTOUR

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

PROTOTYPE 300 0 300 600 900 1200 1500 1800

MODEL

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-D1

FLOOD FLOW HOUR 6

PHOTO 64

NOTE: JETTIES EXTENDED TO -8 FT CONTOUR

VELOCITY SCALE

1 0 1 2 3 4 5 6 7 8

FPS, PROTOTYPE

SCALES IN FEET

300 0 300 600 900 1200 1500 1800

PROTOTYPE

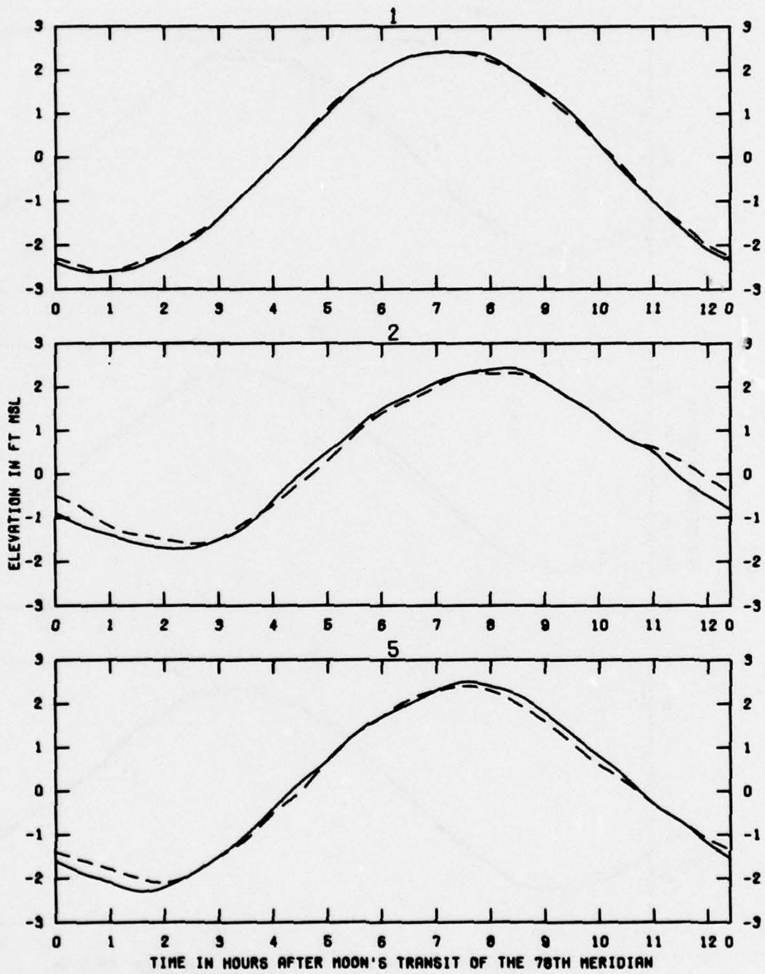
MODEL

SURFACE CURRENTS

1974 CONDITIONS
WITH PLAN 2-D1

EBB FLOW HOUR 9

PHOTO 65

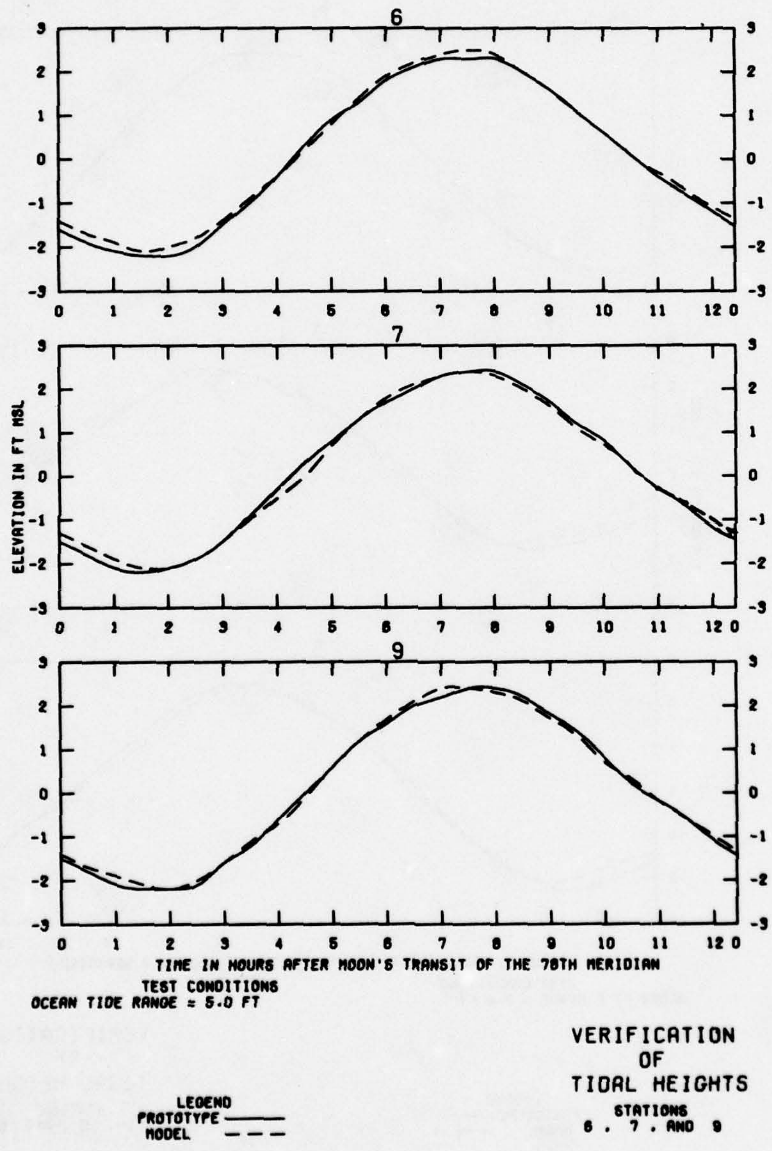



TEST CONDITIONS
OCEAN TIDE RANGE = 5.0 FT

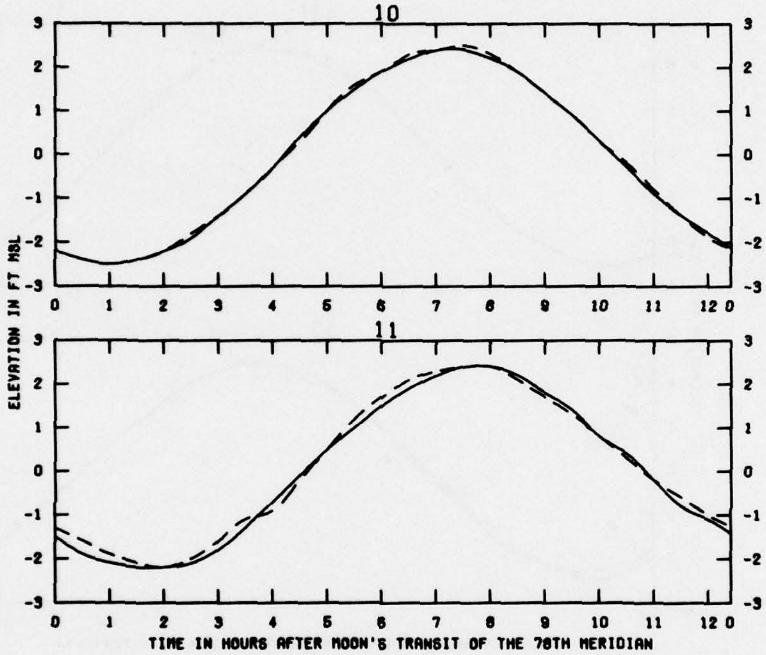
LEGEND
PROTOTYPE ———
MODEL — — —

VERIFICATION
OF
TIDAL HEIGHTS
STATIONS
1 , 2 , AND 5

PLATE 1




VERIFICATION
OF
TIDAL HEIGHTS
STATIONS
6, 7, AND 9



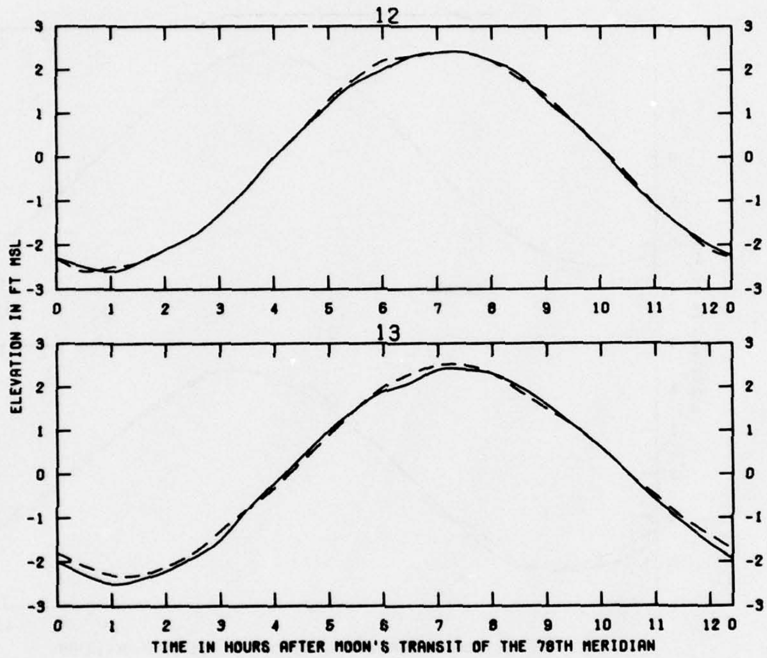

TEST CONDITIONS
OCEAN TIDE RANGE = 5.0 FT

LEGEND
PROTOTYPE ———
MODEL – – –

VERIFICATION
OF
TIDAL HEIGHTS

STATIONS
10 AND 11

PLATE 3



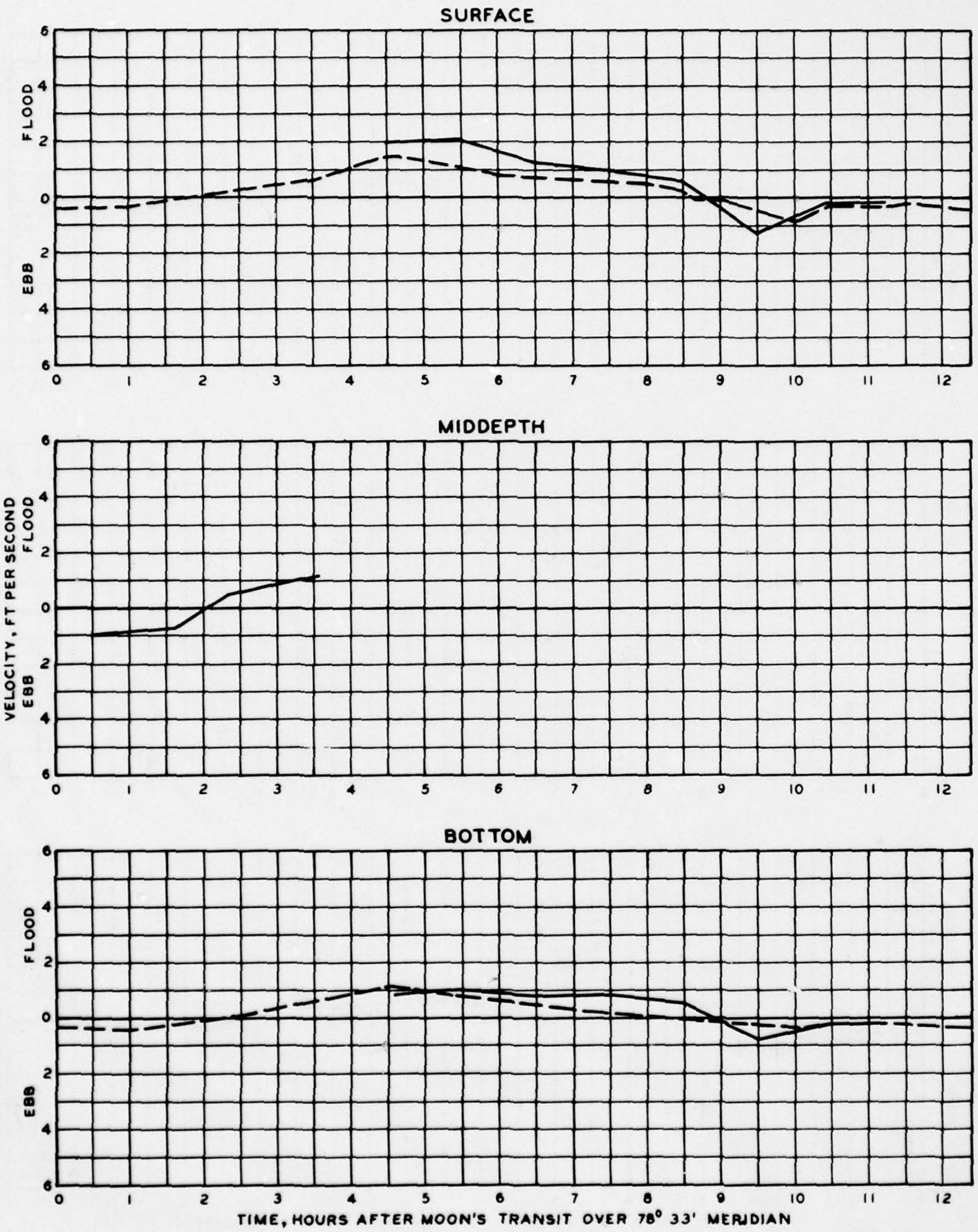

TEST CONDITIONS
OCEAN TIDE RANGE = 5.0 FT

LEGEND
PROTOTYPE ———
MODEL – – –

VERIFICATION
OF
TIDAL HEIGHTS

STATIONS
12 AND 13

PLATE 4




**LEGEND**

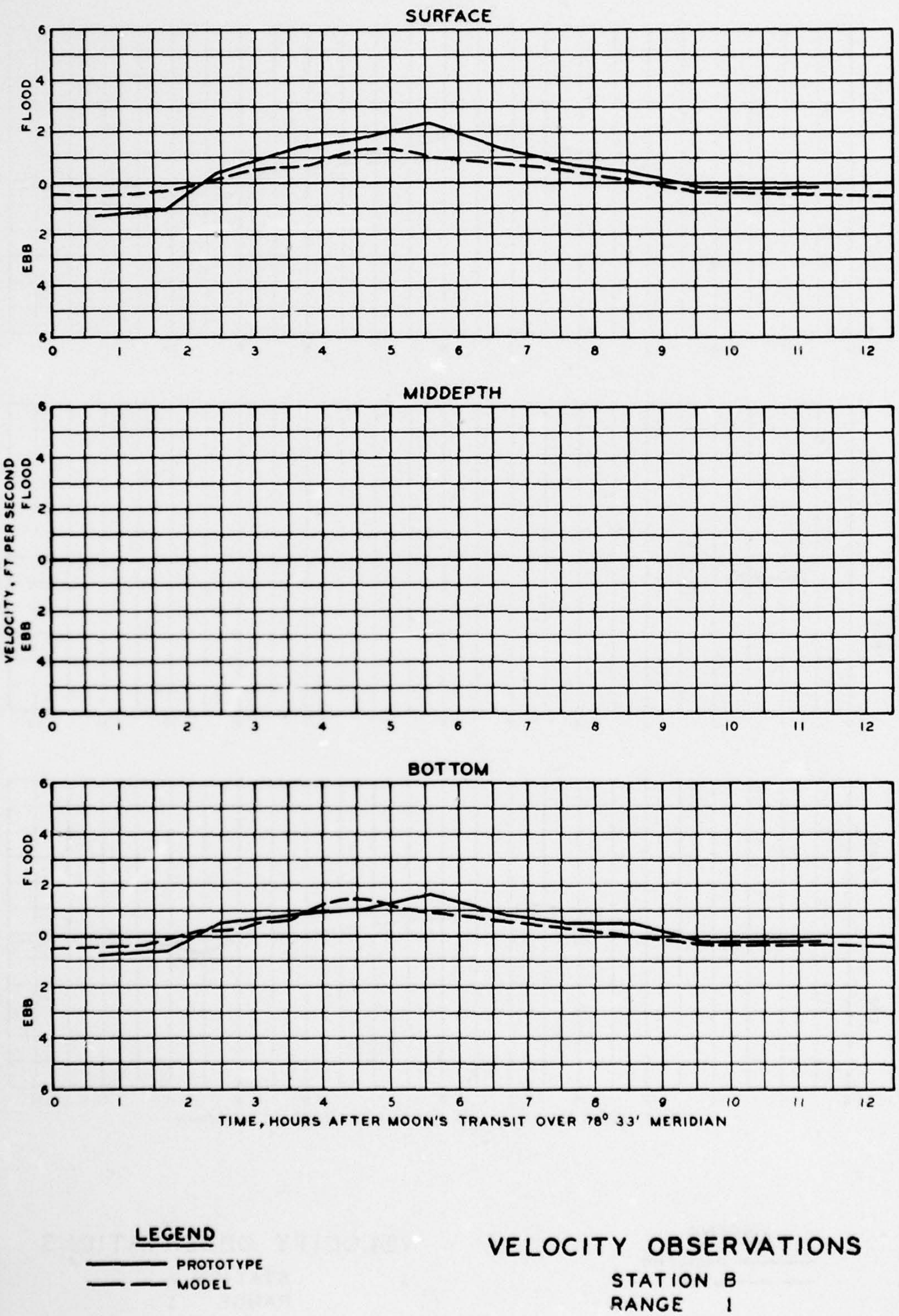
PROTOTYPE (solid line)

MODEL (dashed line)

## VELOCITY OBSERVATIONS

STATION A

RANGE 1

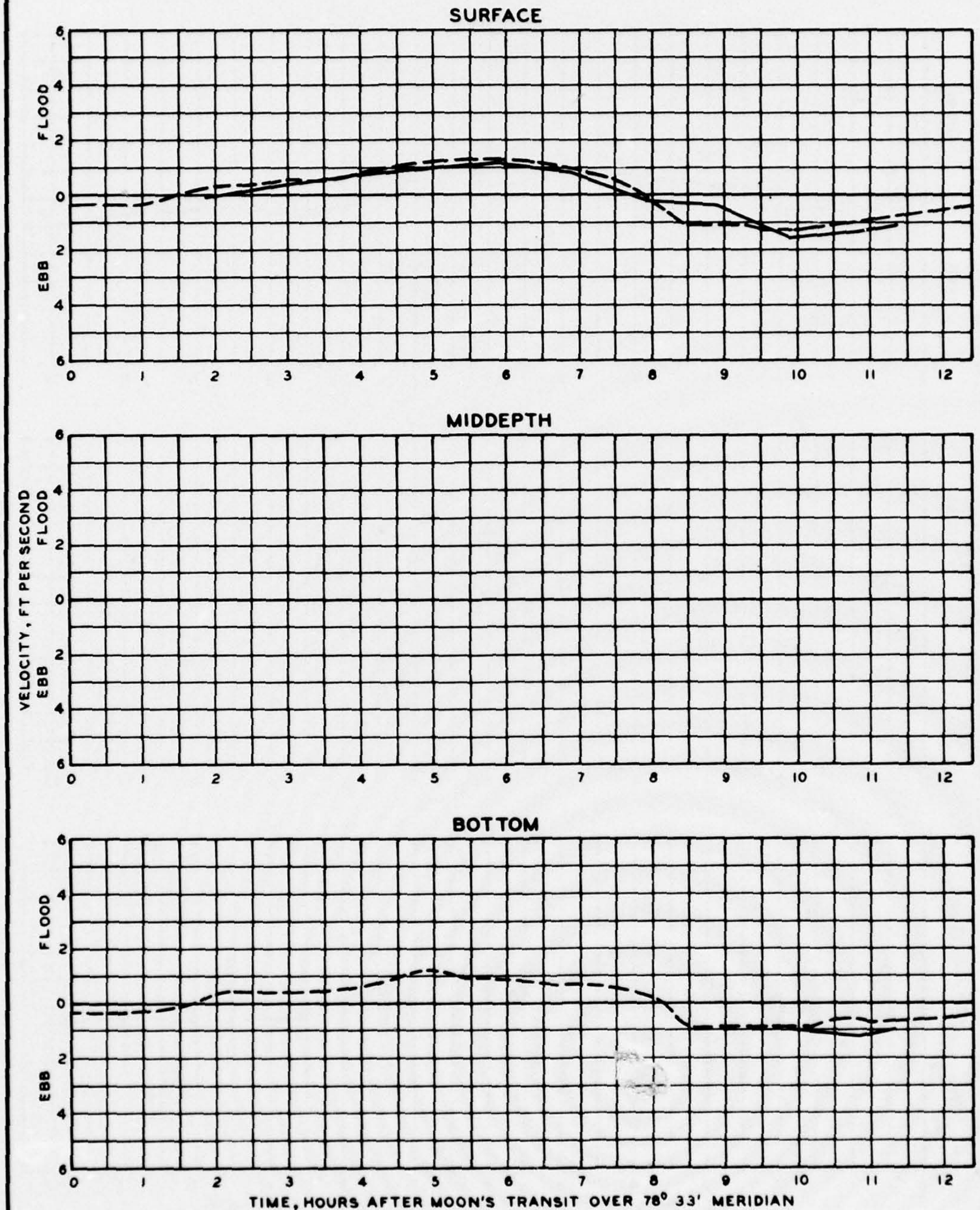



VELOCITY OBSERVATIONS

STATION B

RANGE 1

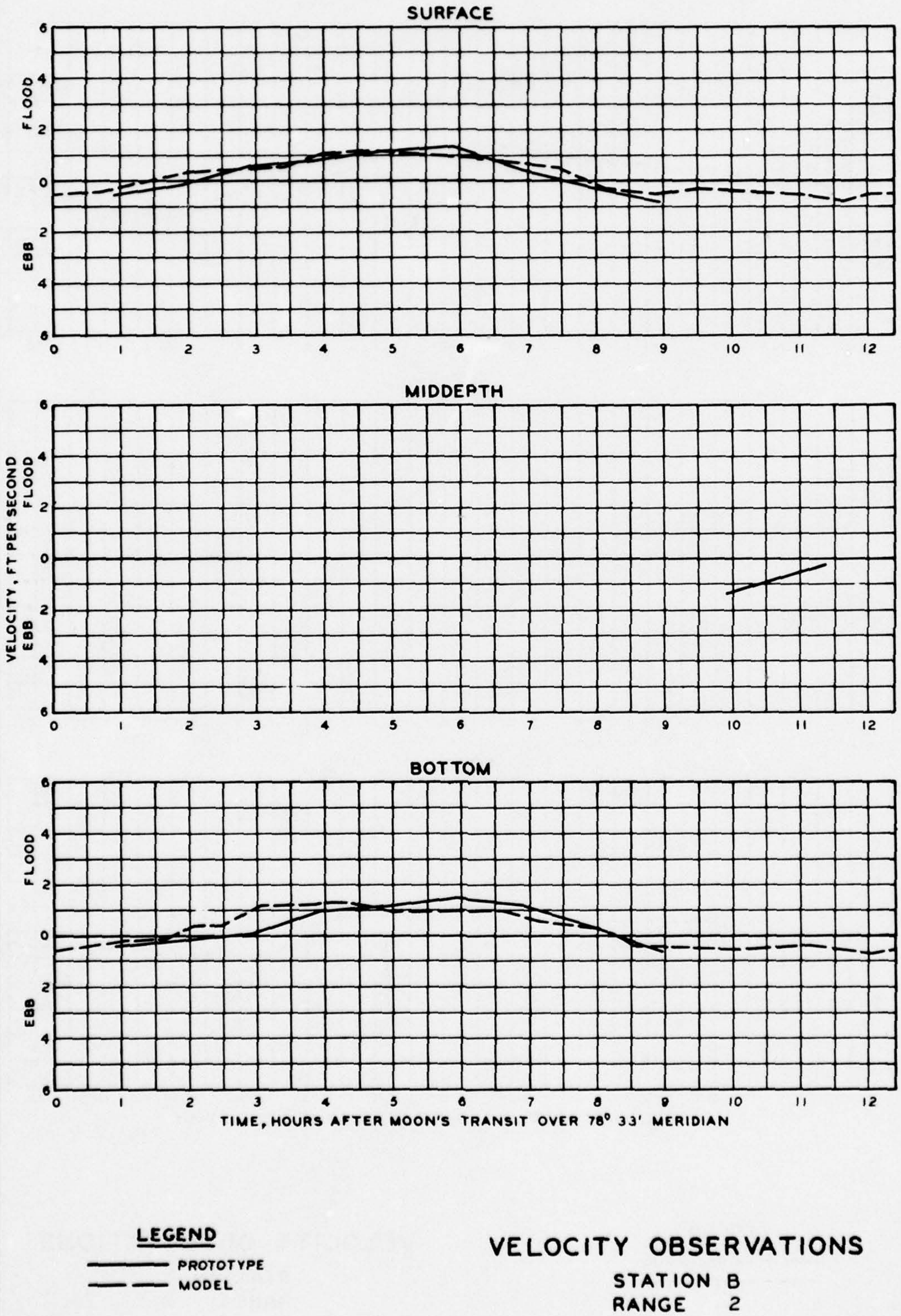
PLATE 6




VELOCITY OBSERVATIONS

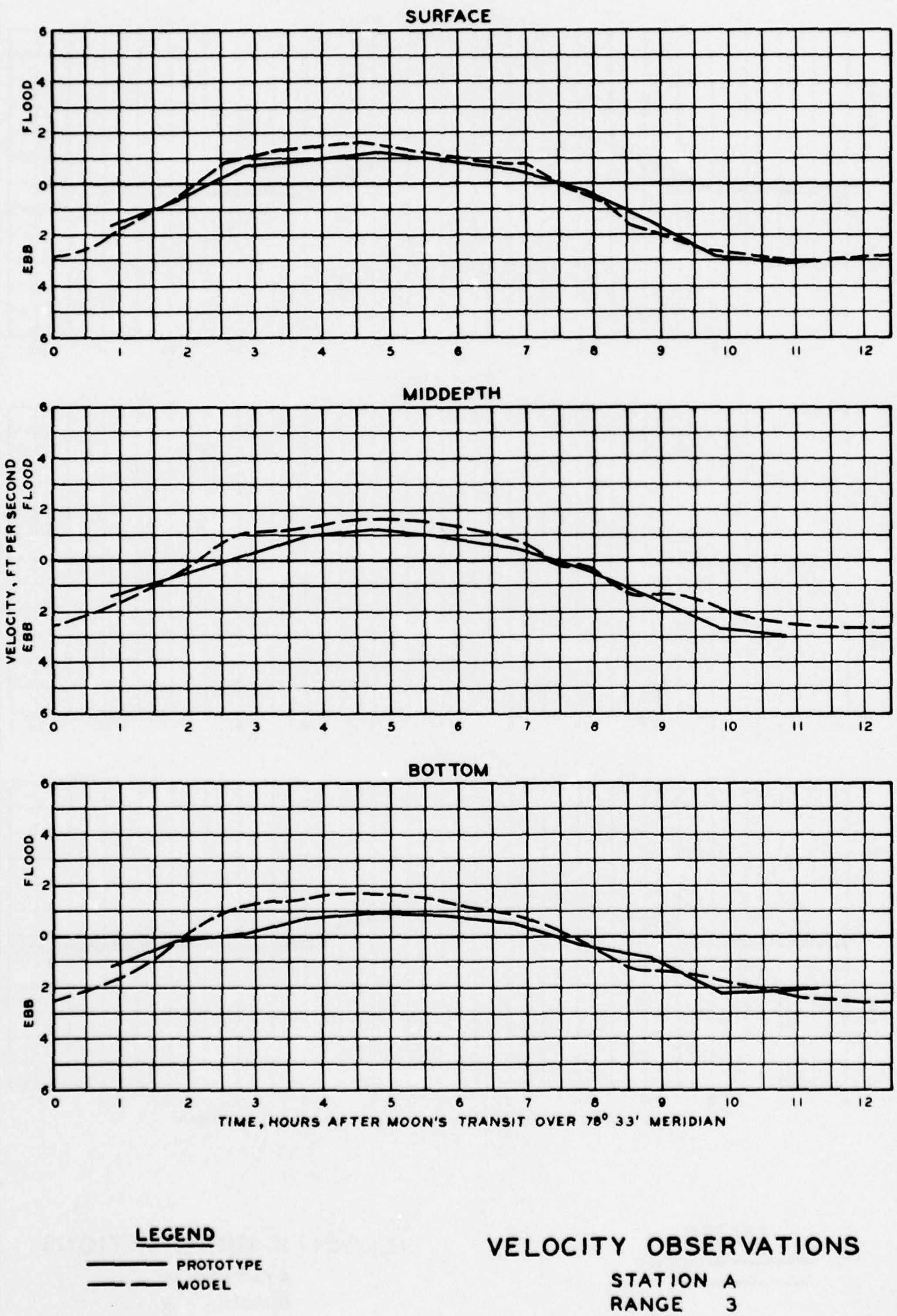
STATION A
RANGE 2

PLATE 7




VELOCITY OBSERVATIONS

STATION B
RANGE 2




VELOCITY OBSERVATIONS

STATION A
RANGE 3

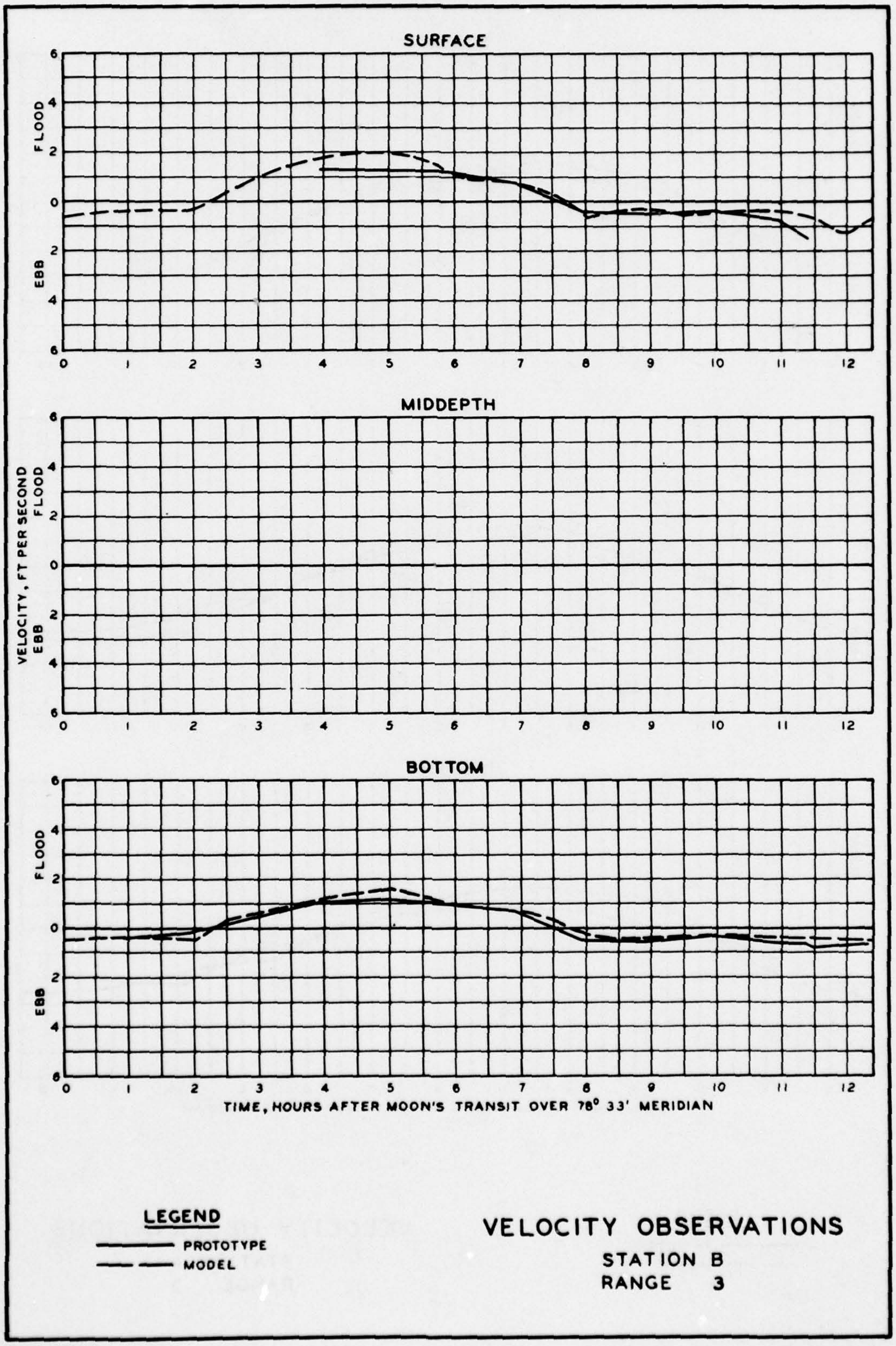
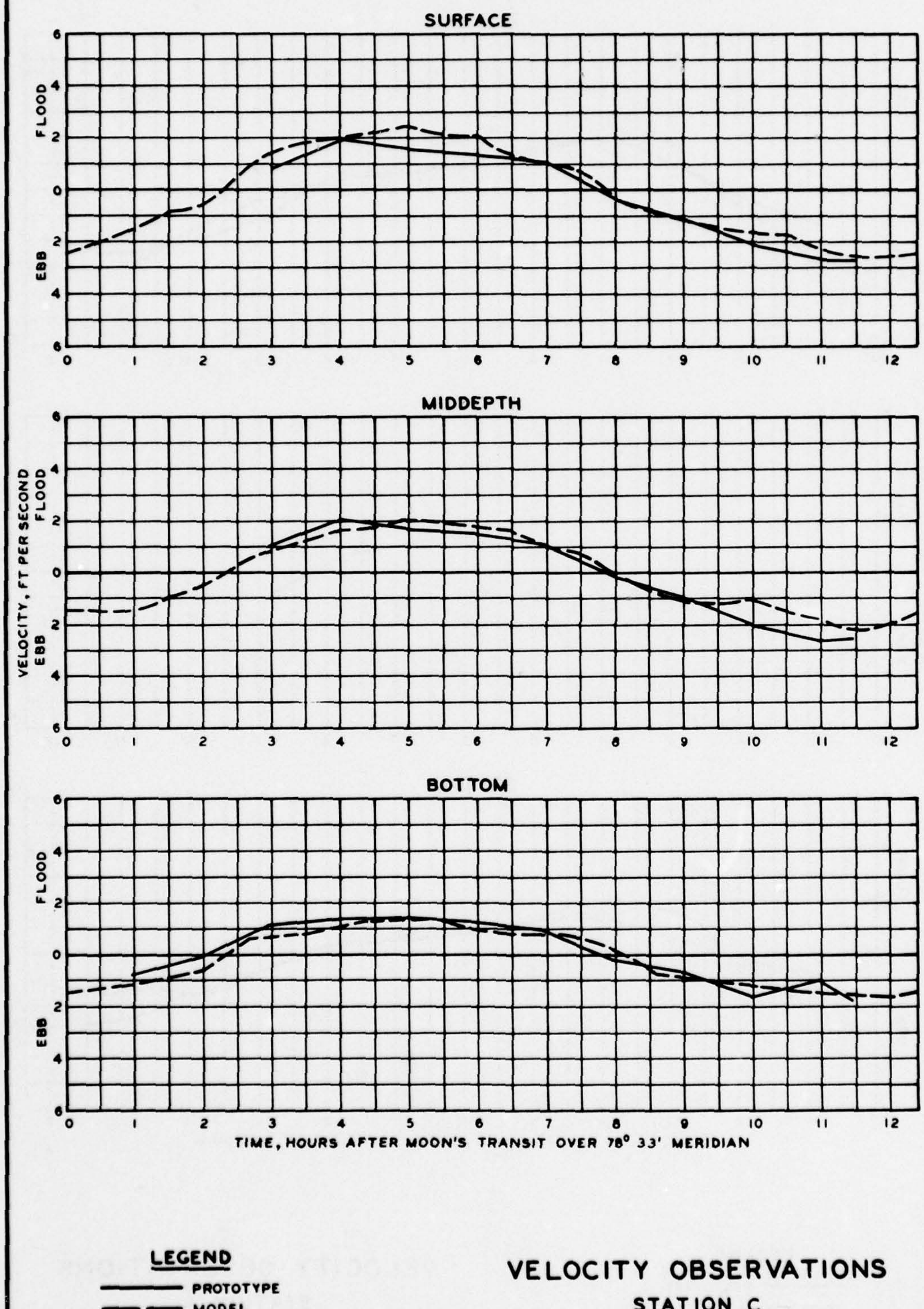
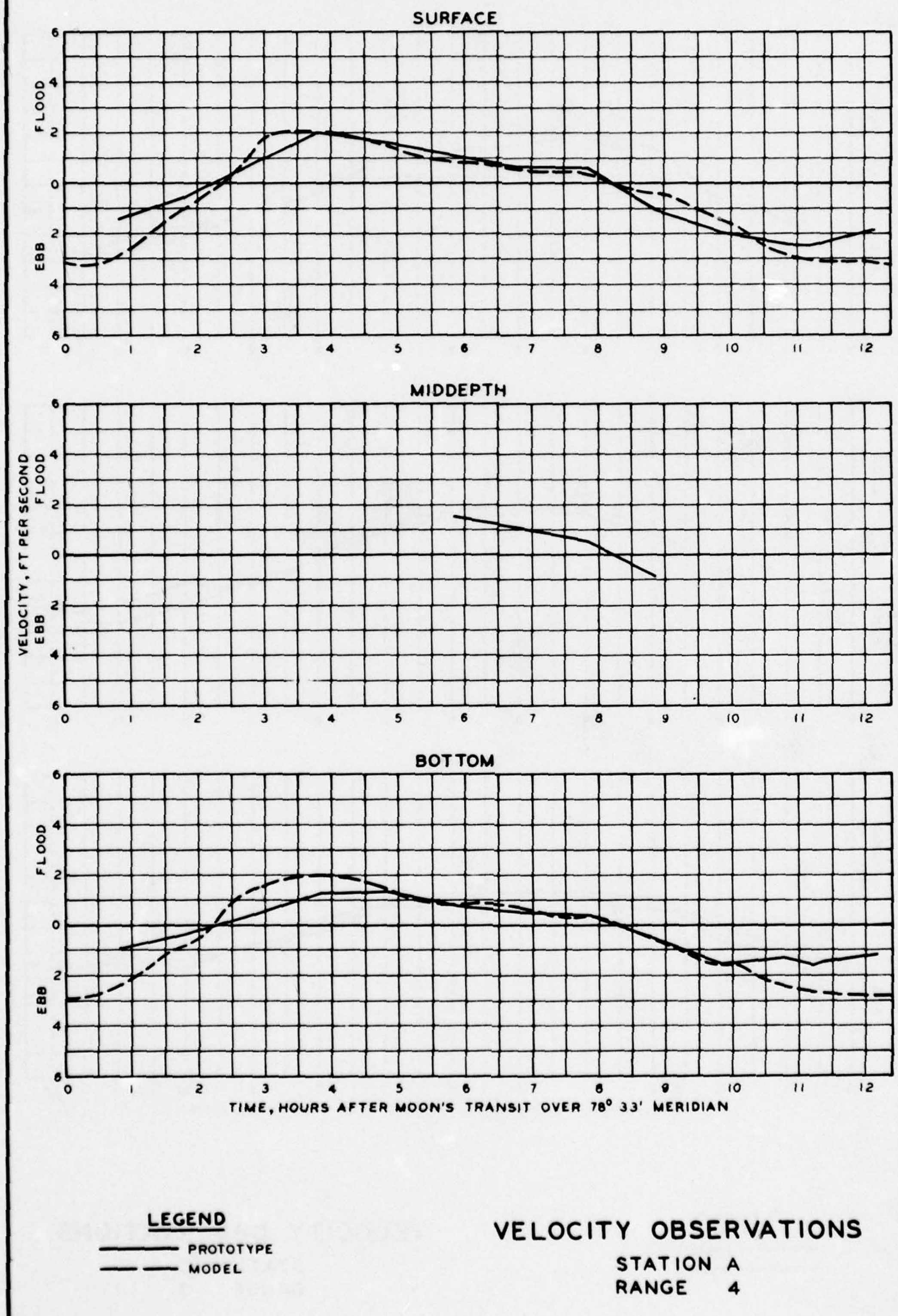

SURFACE
MIDDEPTH
BOTTOM
VELOCITY, FT PER SECOND
FLOOD
EBB
TIME, HOURS AFTER MOON'S TRANSIT OVER 78° 33' MERIDIAN
LEGEND
PROTOTYPE
MODEL
VELOCITY OBSERVATIONS
STATION B
RANGE 3

PLATE 10




VELOCITY OBSERVATIONS

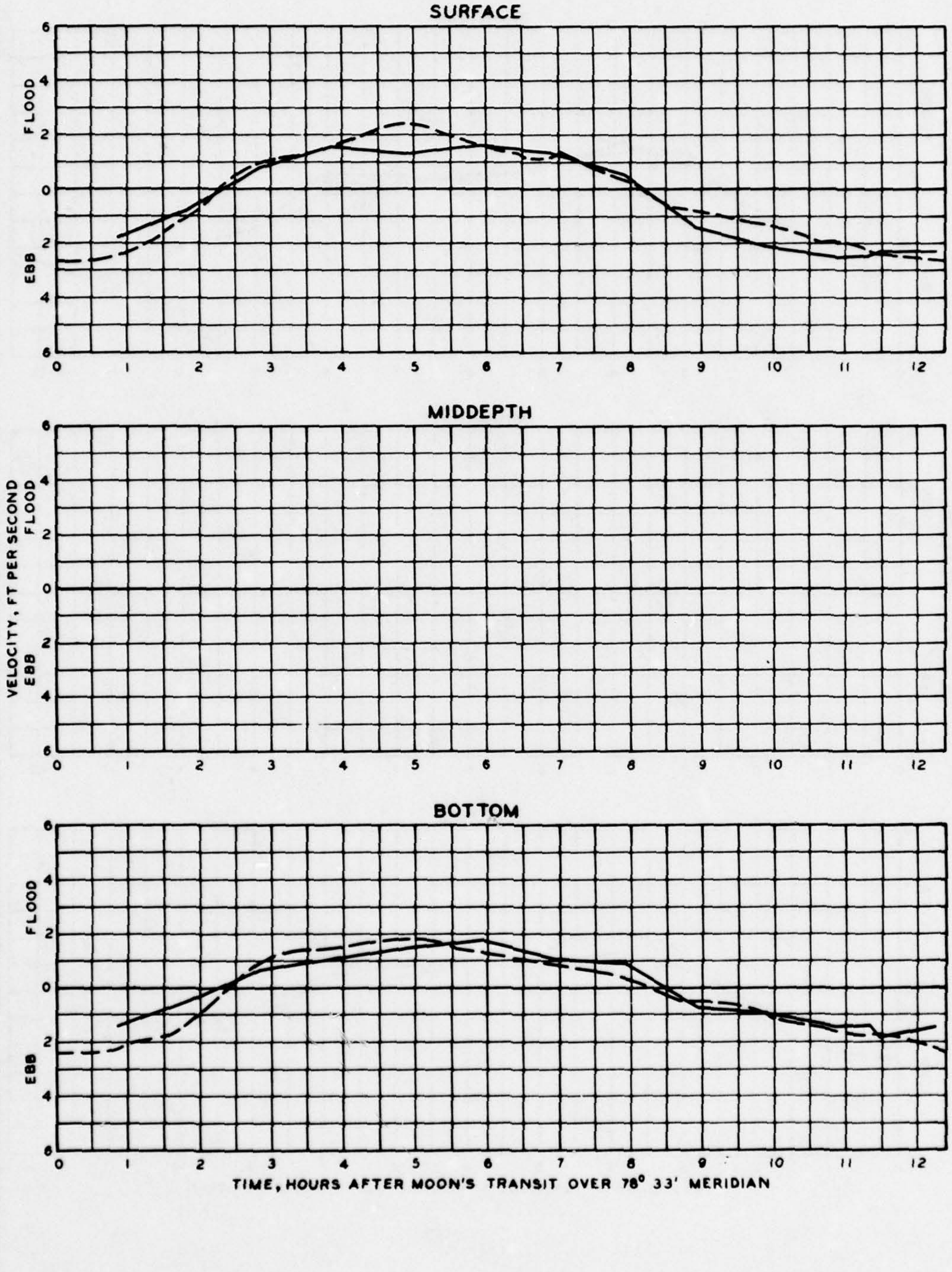
STATION C
RANGE 3




VELOCITY OBSERVATIONS

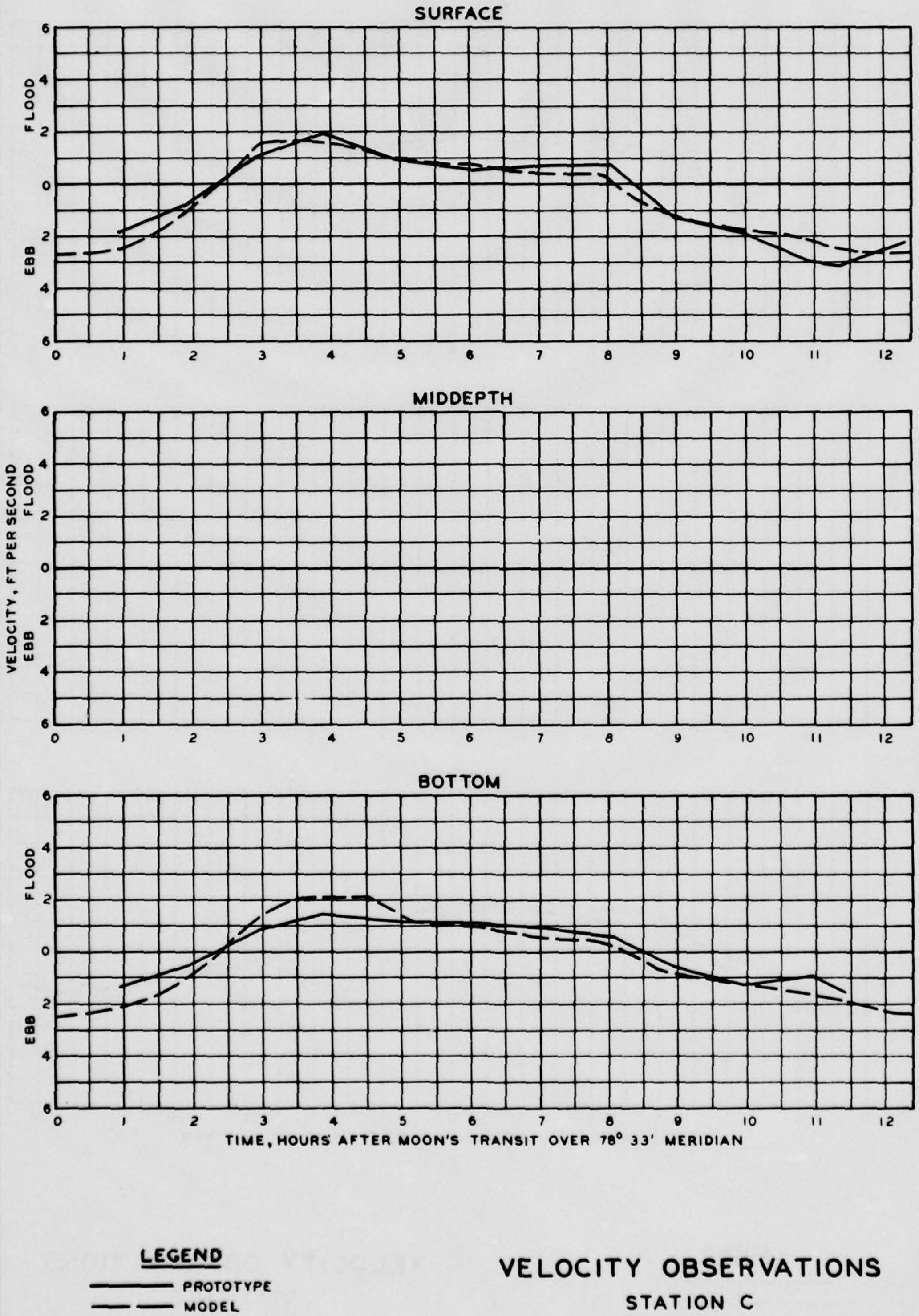
STATION A

RANGE 4




# VELOCITY OBSERVATIONS

STATION B
RANGE 4

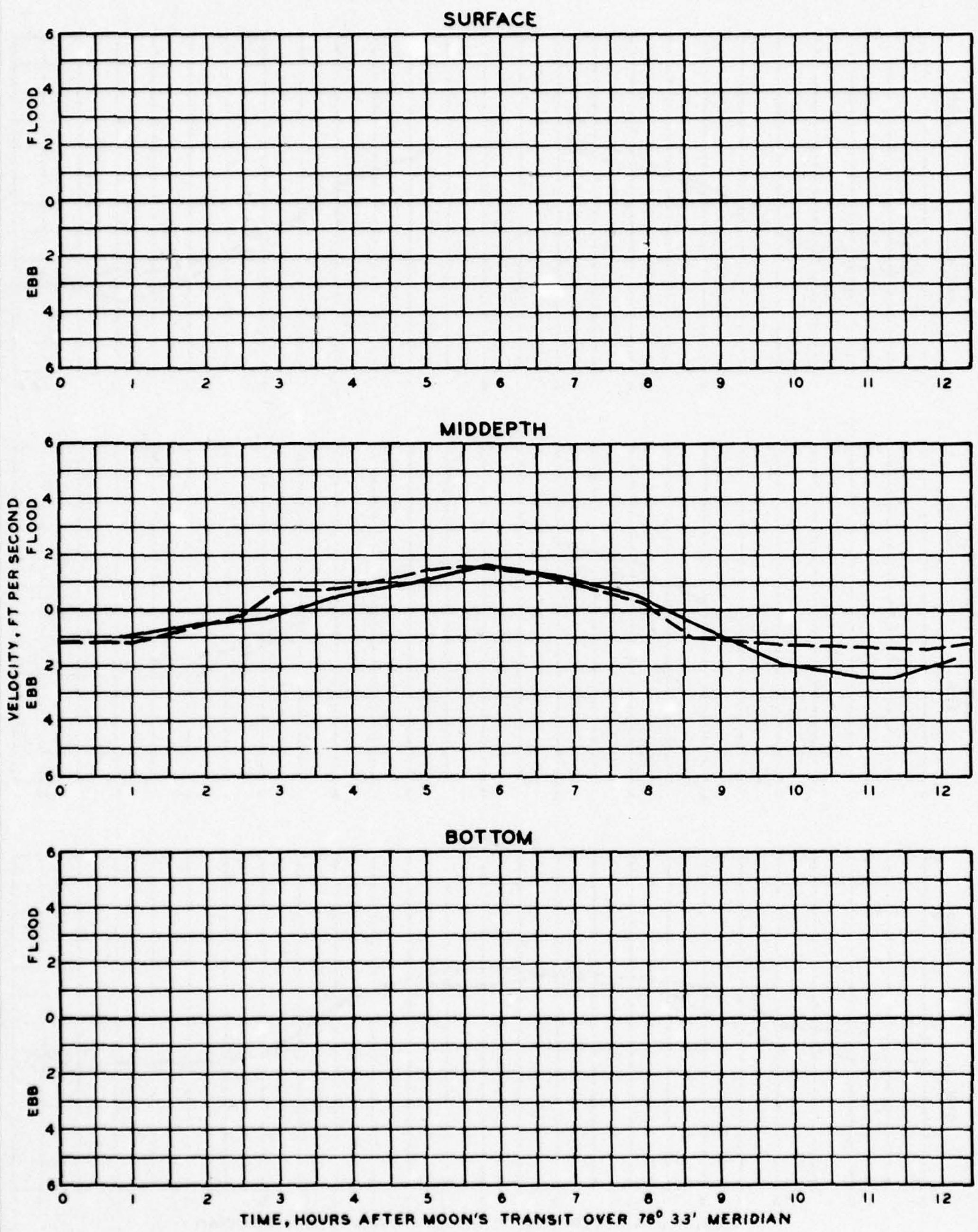



# VELOCITY OBSERVATIONS

STATION C

RANGE 4

PLATE 14




LEGEND

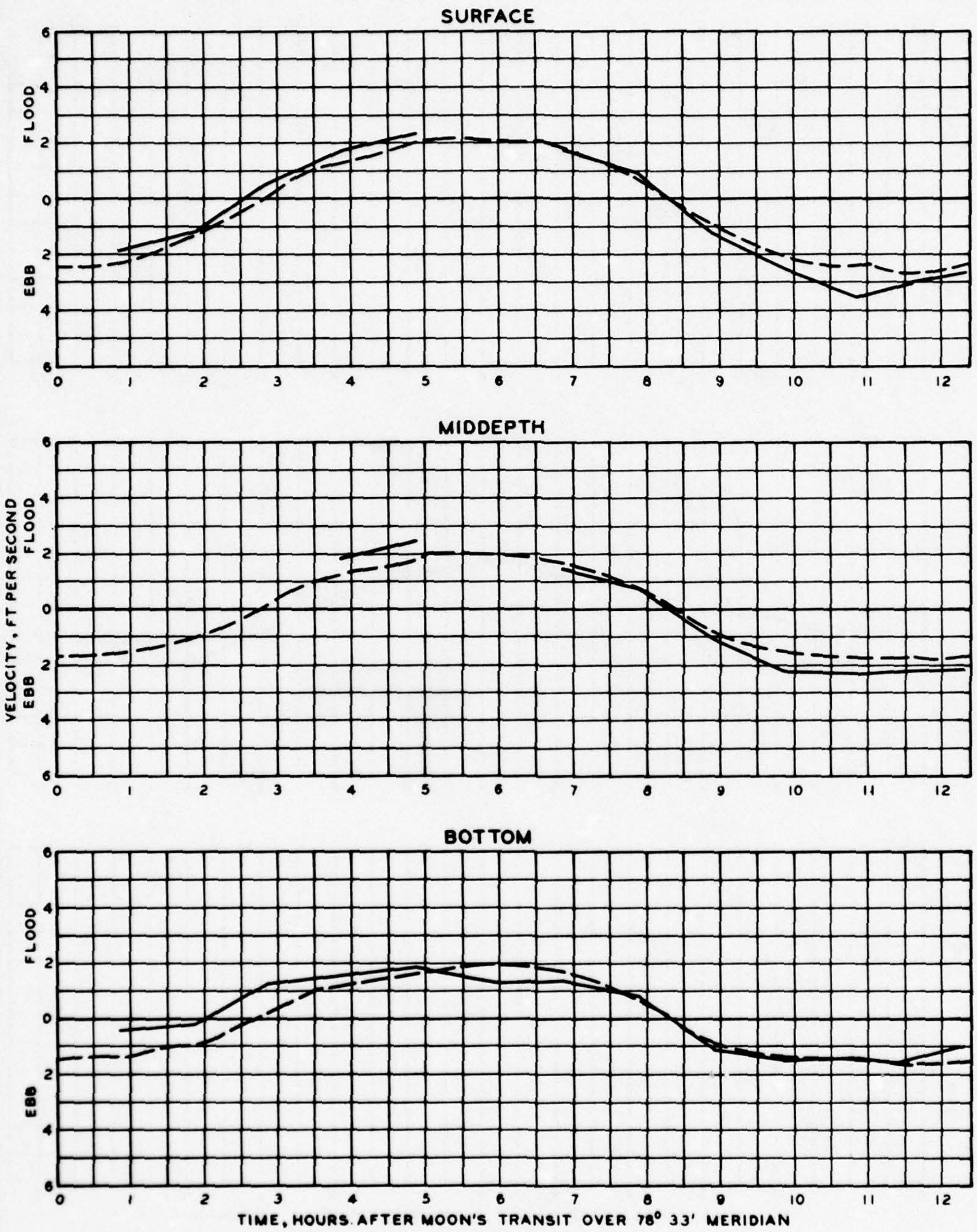
PROTOTYPE

MODEL

VELOCITY OBSERVATIONS

STATION A

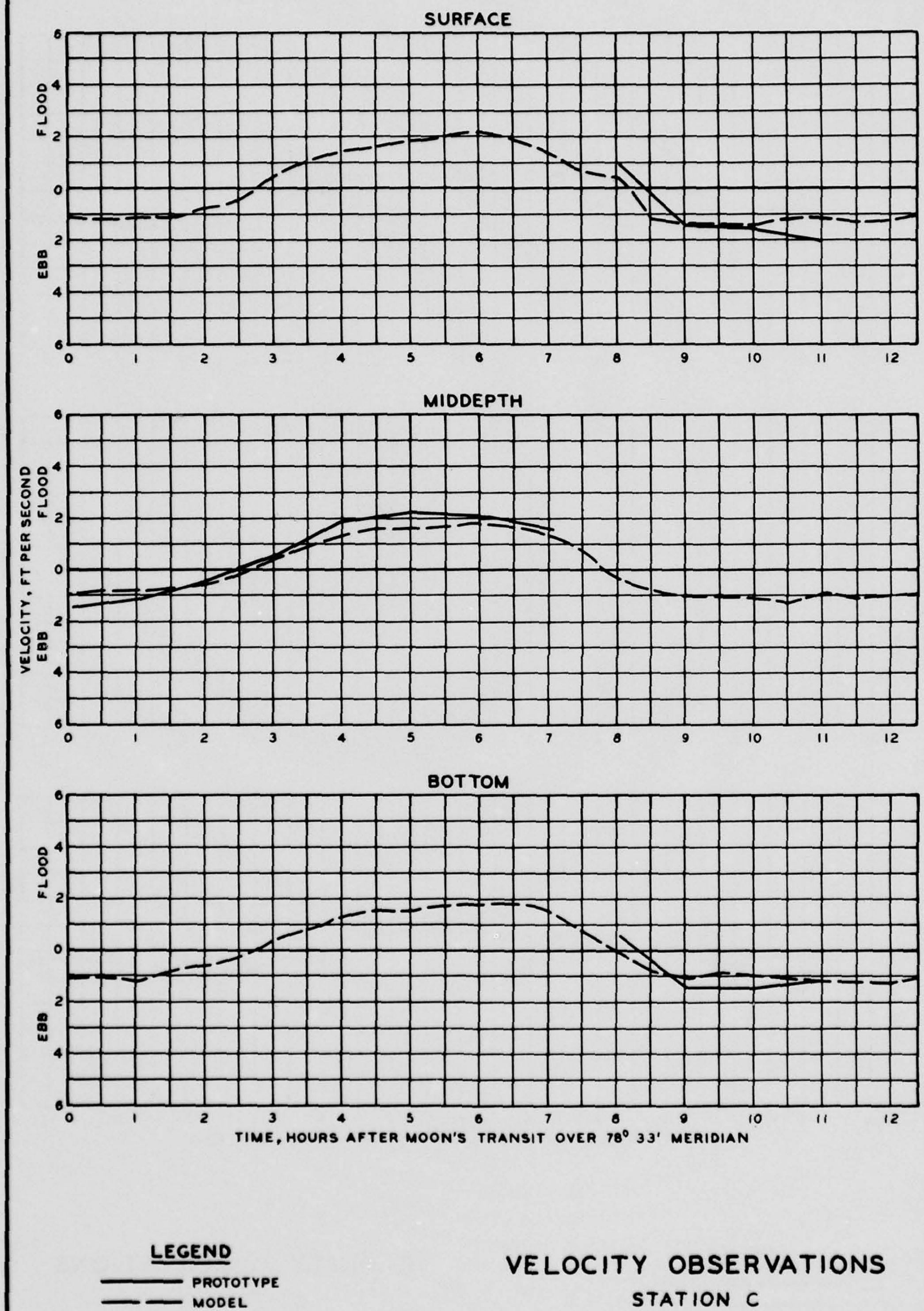
RANGE 5




VELOCITY OBSERVATIONS

STATION B

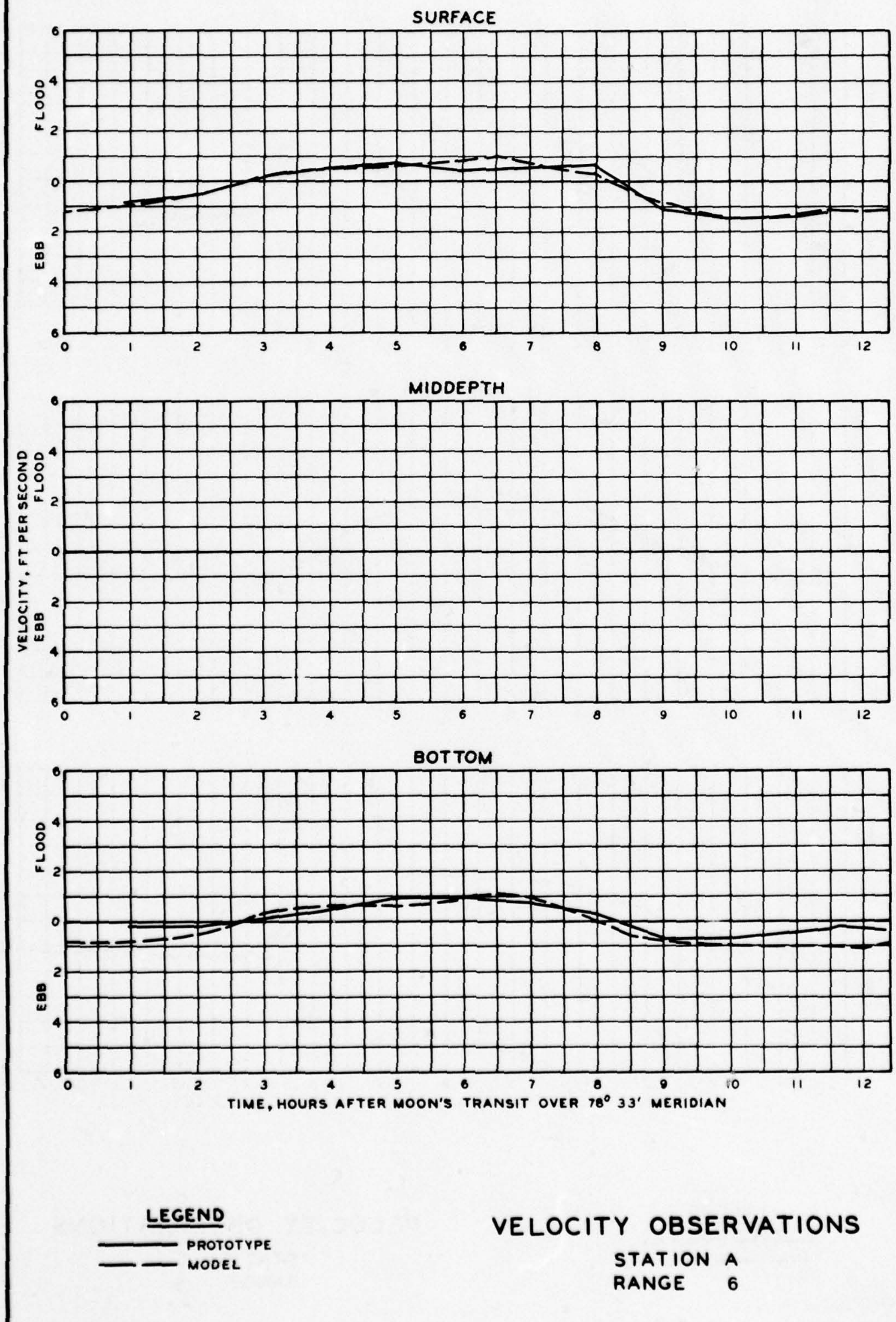
RANGE 5




VELOCITY OBSERVATIONS

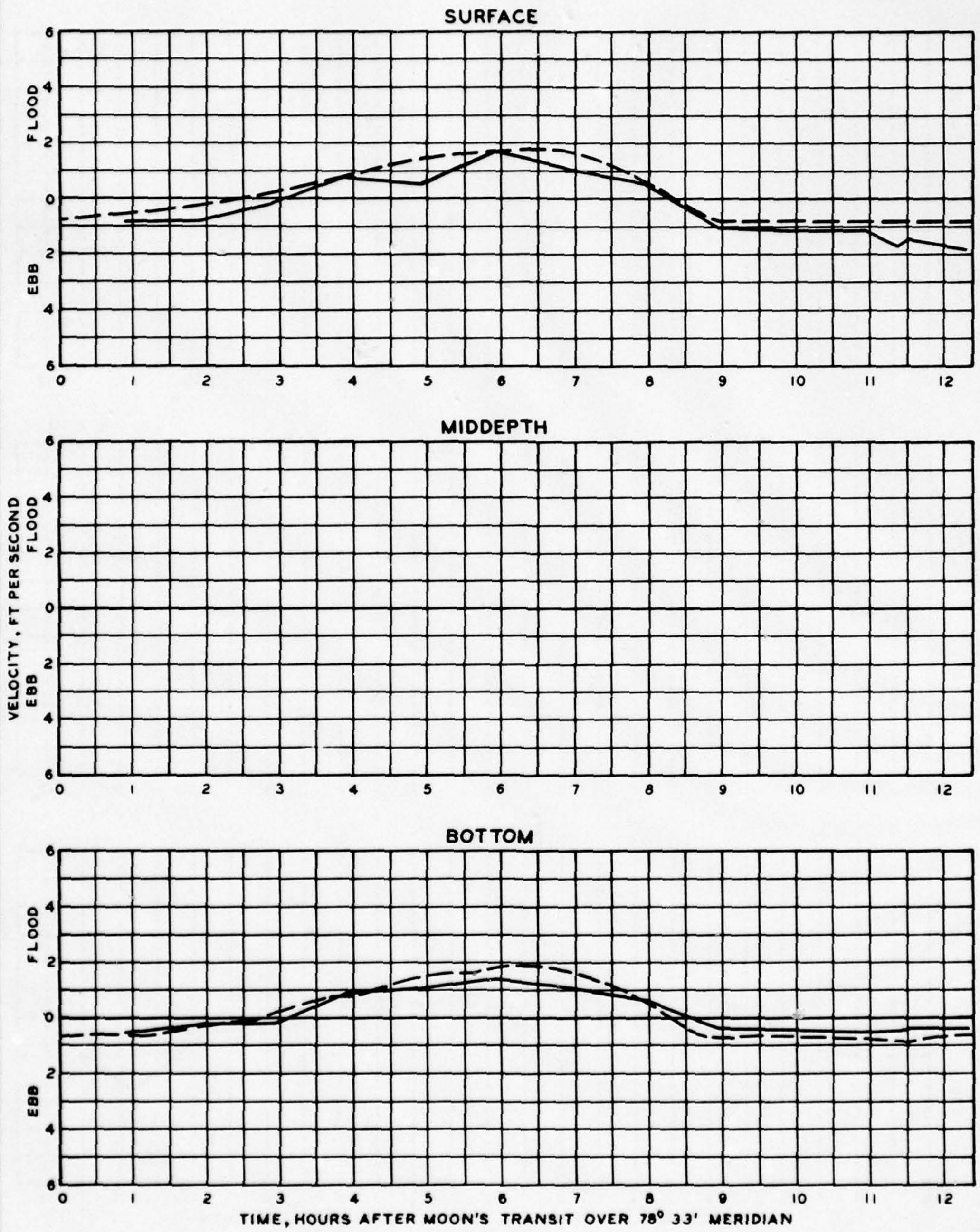
STATION C

RANGE 5




VELOCITY OBSERVATIONS

STATION A
RANGE 6




**LEGEND**

——— PROTOTYPE

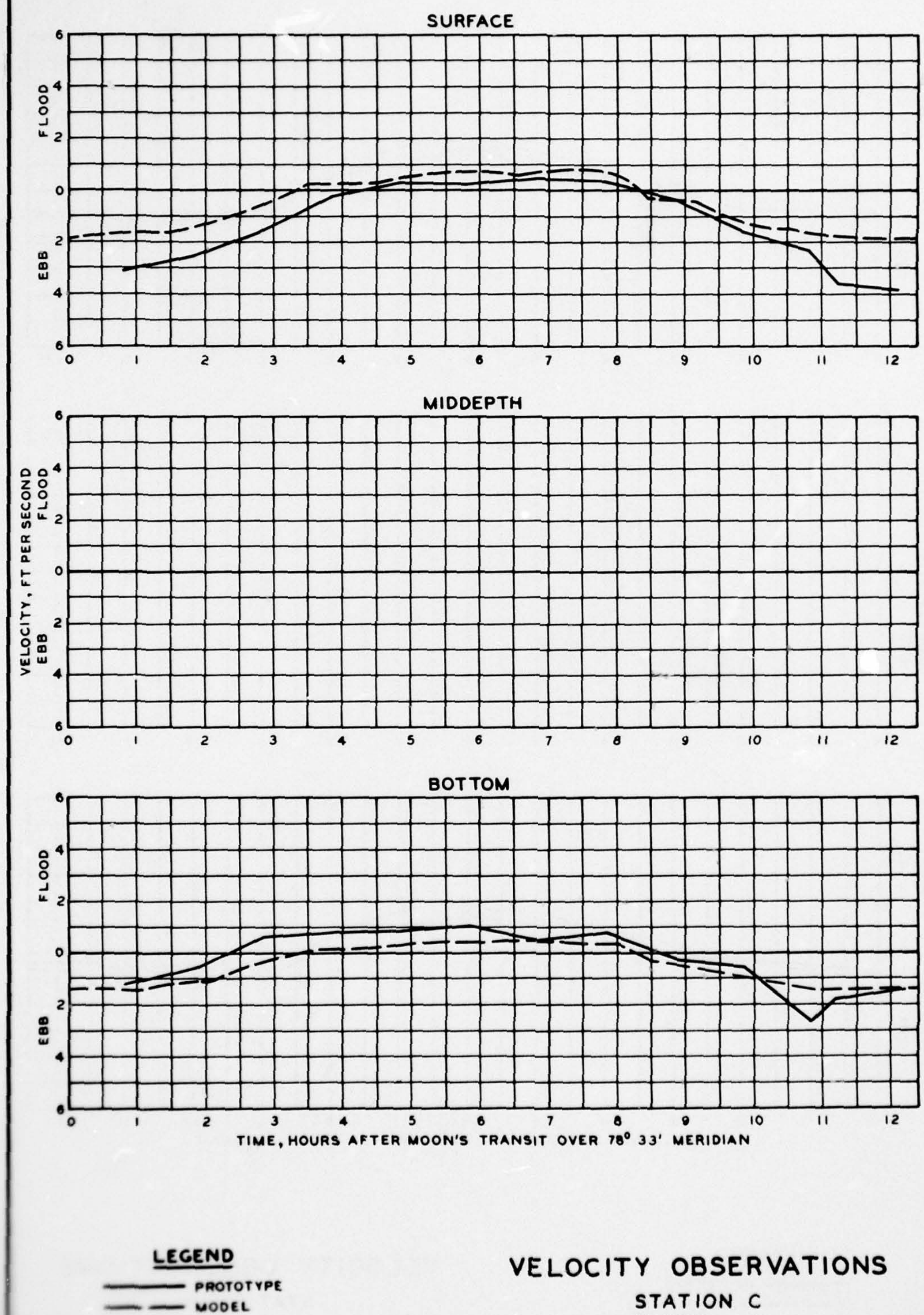
— — — MODEL

**VELOCITY OBSERVATIONS**

**STATION B**

**RANGE 6**

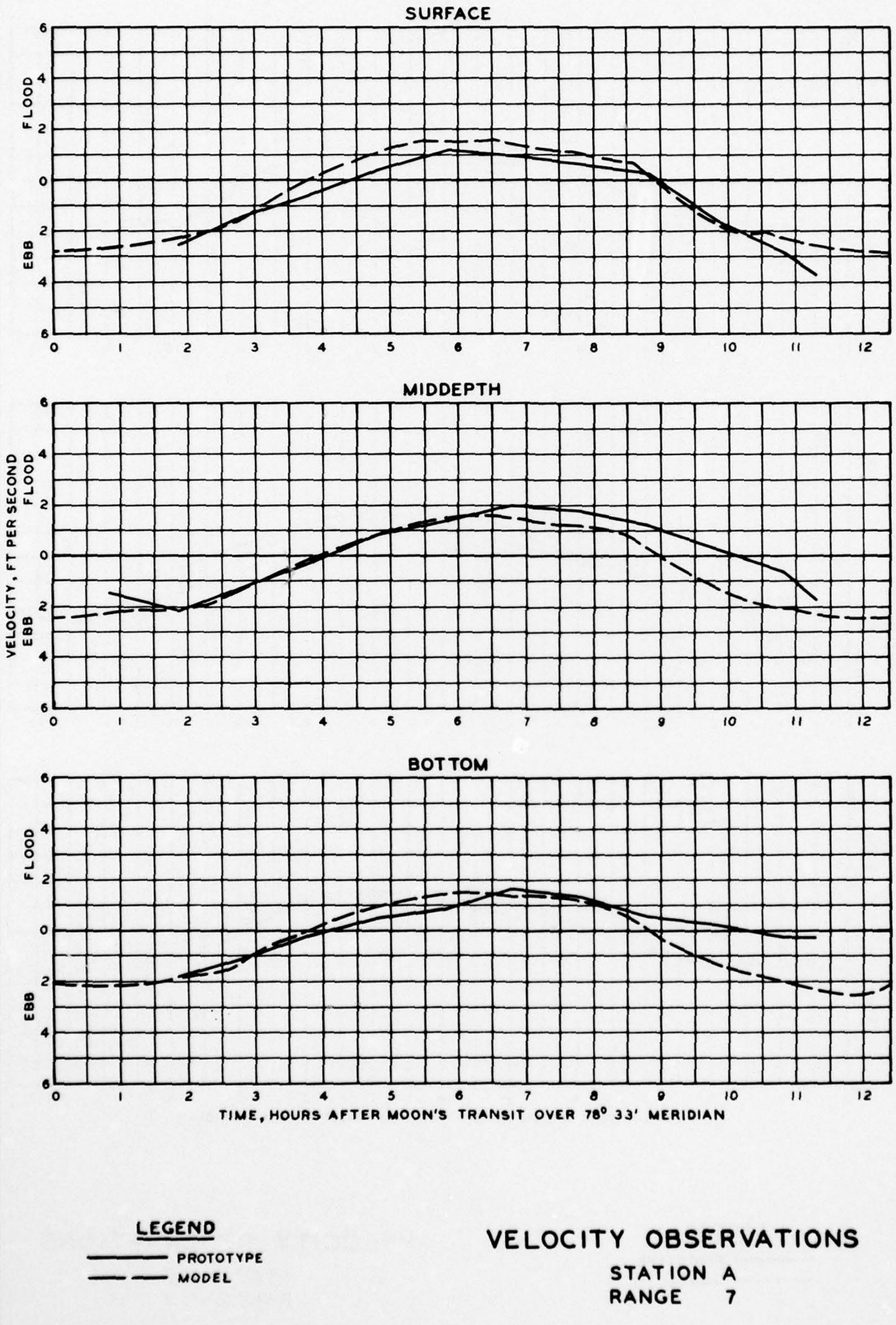
PLATE 19




VELOCITY OBSERVATIONS

STATION C

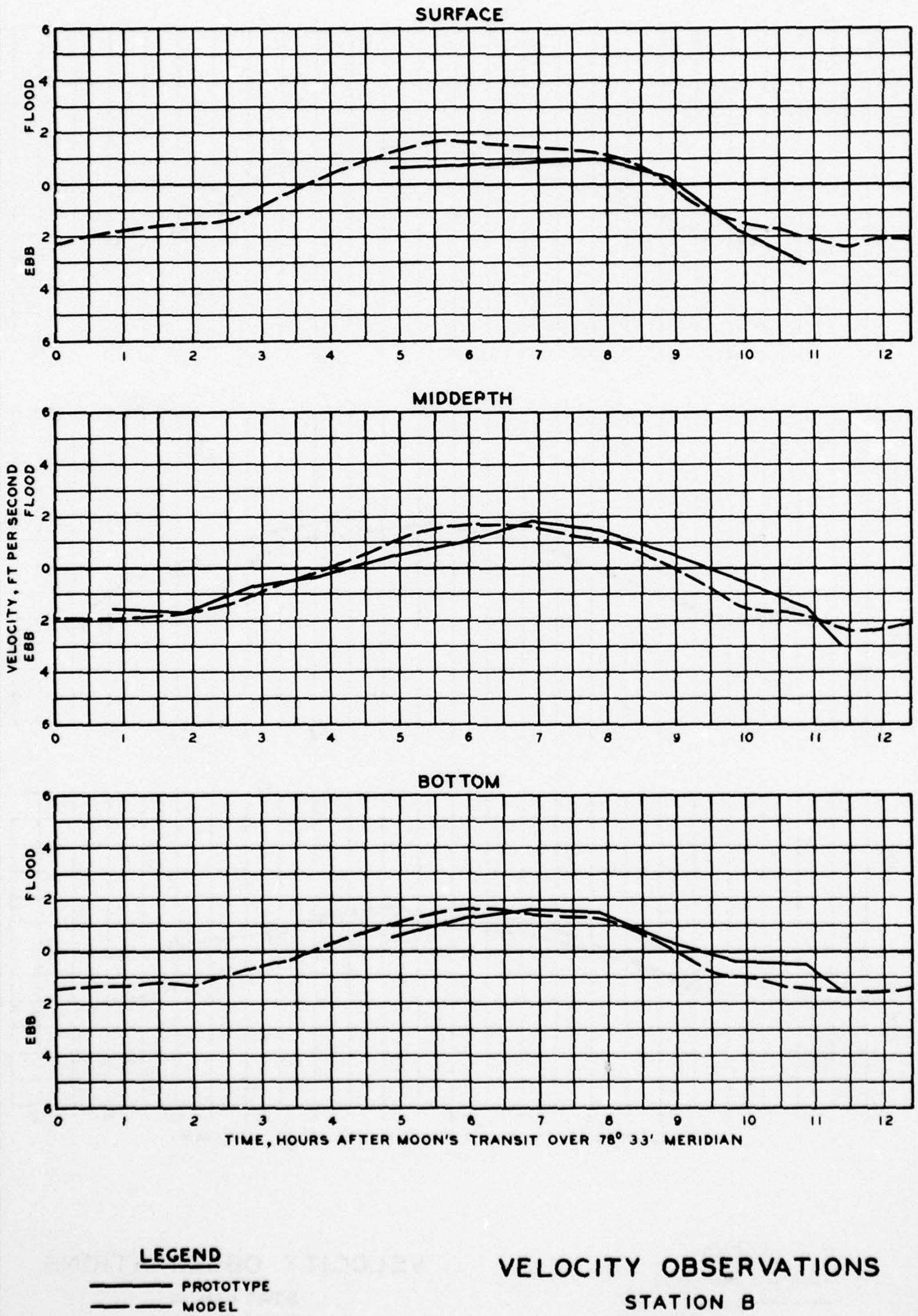
RANGE 6




VELOCITY OBSERVATIONS

STATION A

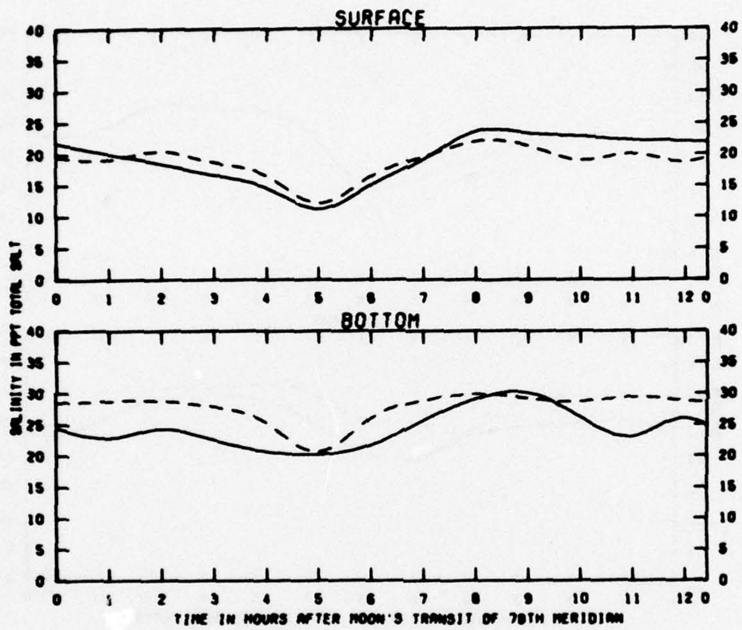
RANGE 7




VELOCITY OBSERVATIONS

STATION B

RANGE 7




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

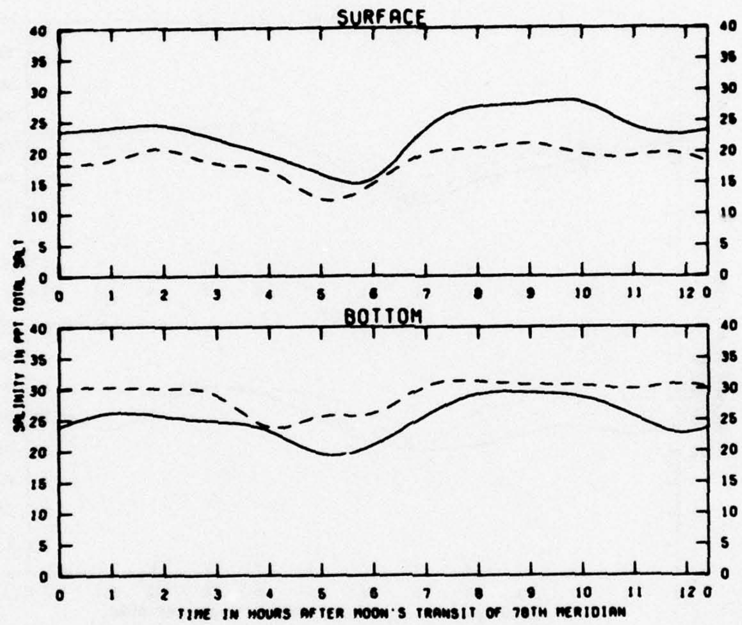
LEGEND

——— PROTOTYPE

– – – MODEL

VERIFICATION OF SALINITIES

STATION 1A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

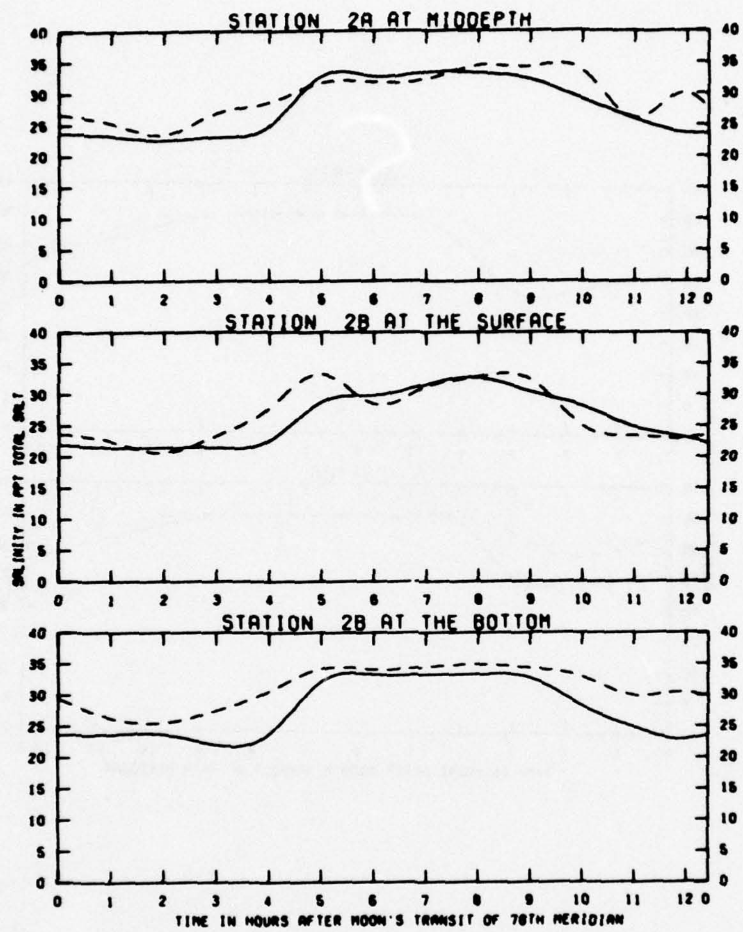
LEGEND

——— PROTOTYPE

– – – – MODEL

VERIFICATION
OF SALINITIES

STATION
1B




**TEST CONDITIONS**

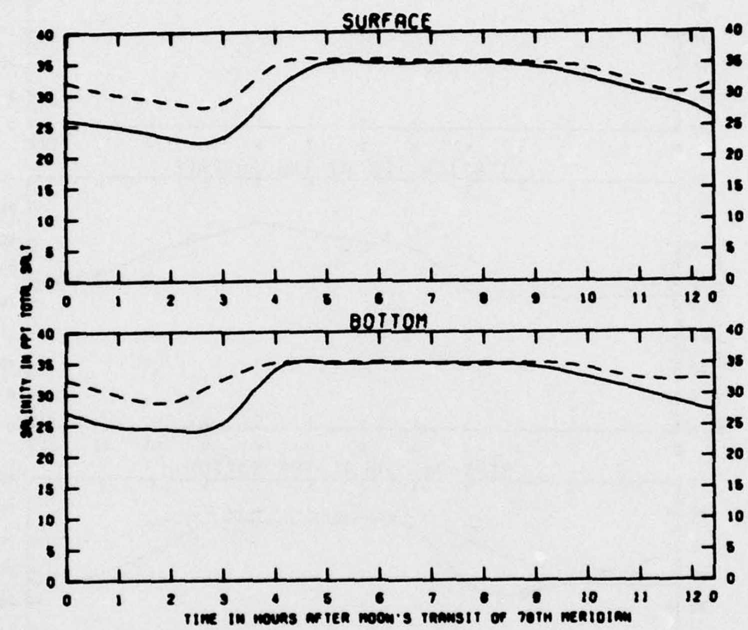
OCEAN TIDE RANGE = 5.0 FT

**LEGEND**

——— PROTOTYPE

– – – MODEL

VERIFICATION
OF SALINITIES
STATION
2A, 2B, AND 2B




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

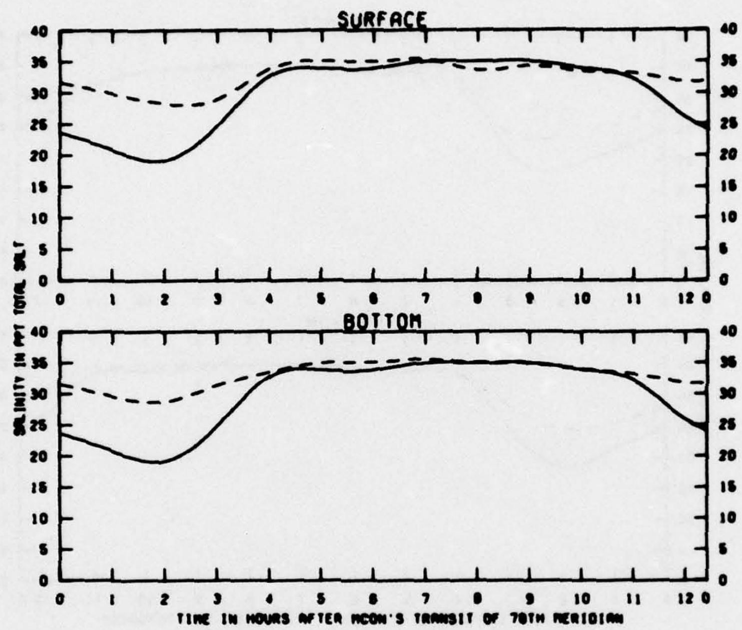
**LEGEND**

——— PROTOTYPE

– – – – MODEL

VERIFICATION OF SALINITIES

STATION 3A




TEST CONDITIONS

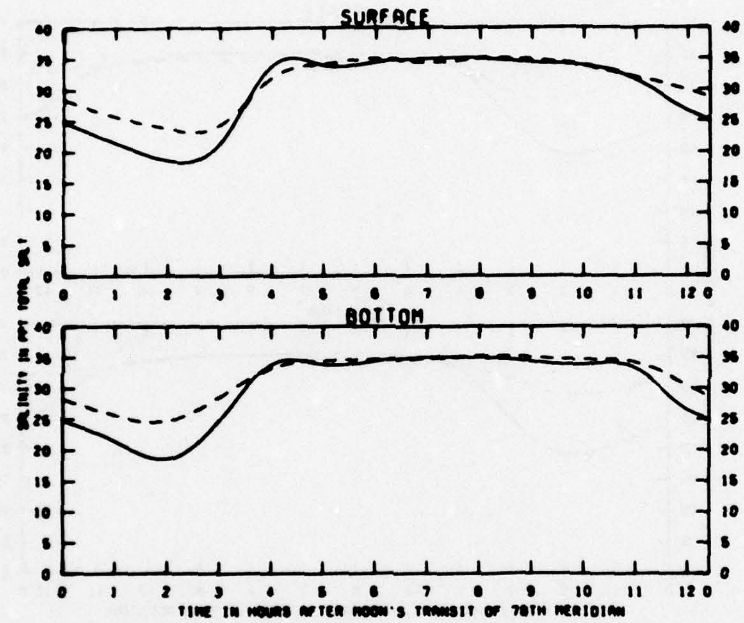
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— PROTOTYPE

– – – – MODEL

VERIFICATION
OF SALINITIES
STATION
3B




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

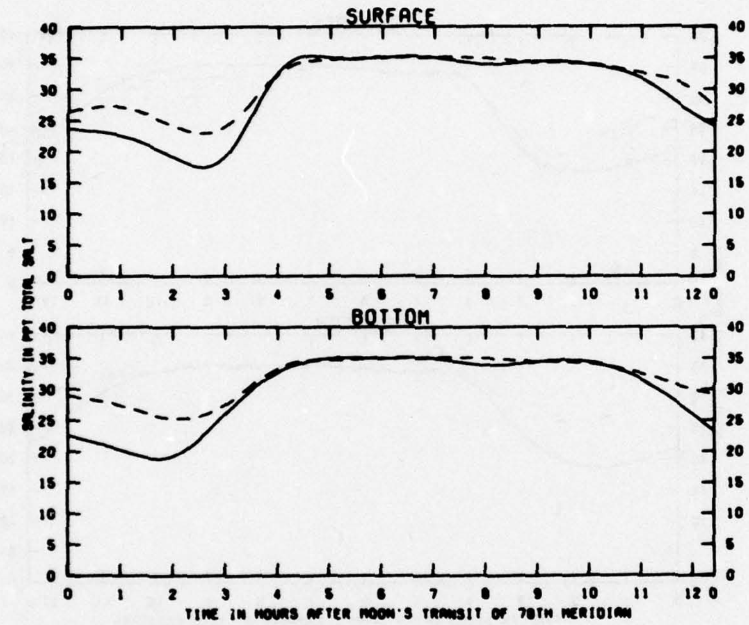
LEGEND

——— PROTOTYPE

– – – MODEL

VERIFICATION OF SALINITIES

STATION 3C




**TEST CONDITIONS**

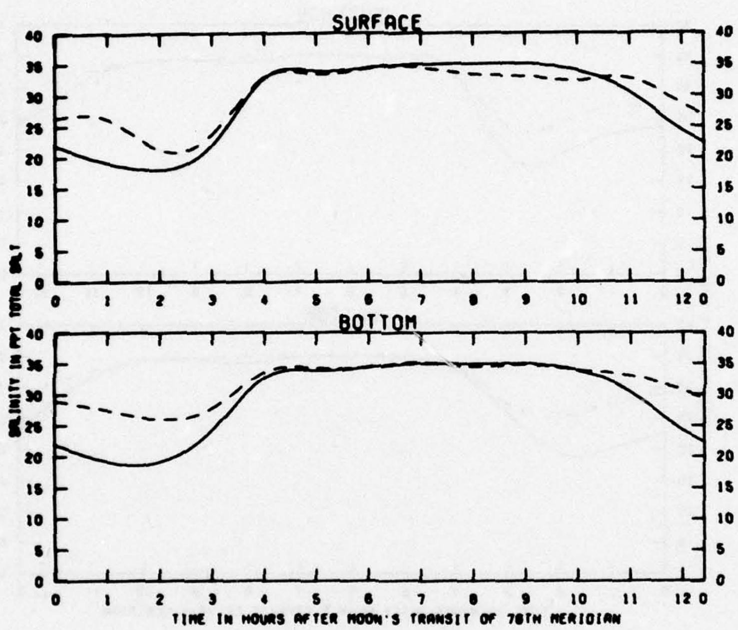
OCEAN TIDE RANGE = 5.0 FT

**LEGEND**

——— PROTOTYPE

– – – – MODEL

VERIFICATION
OF SALINITIES
STATION
4A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

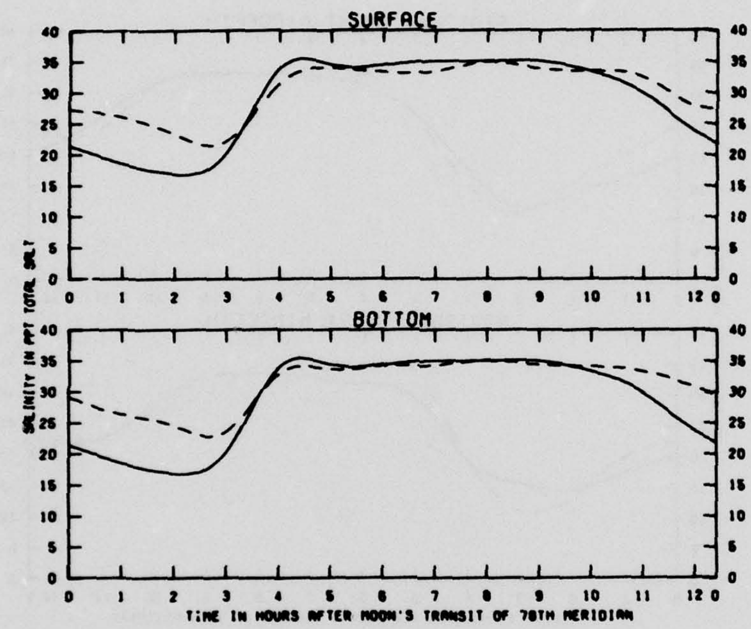
LEGEND

——— PROTOTYPE

– – – – MODEL

VERIFICATION
OF SALINITIES

STATION
4B




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

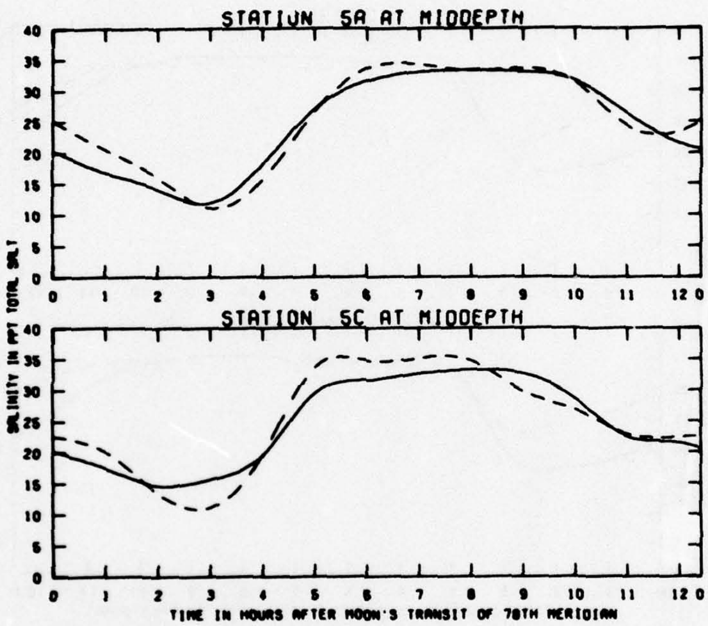
**LEGEND**

——— PROTOTYPE

– – – MODEL

VERIFICATION
OF SALINITIES

STATION
4C




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

**LEGEND**

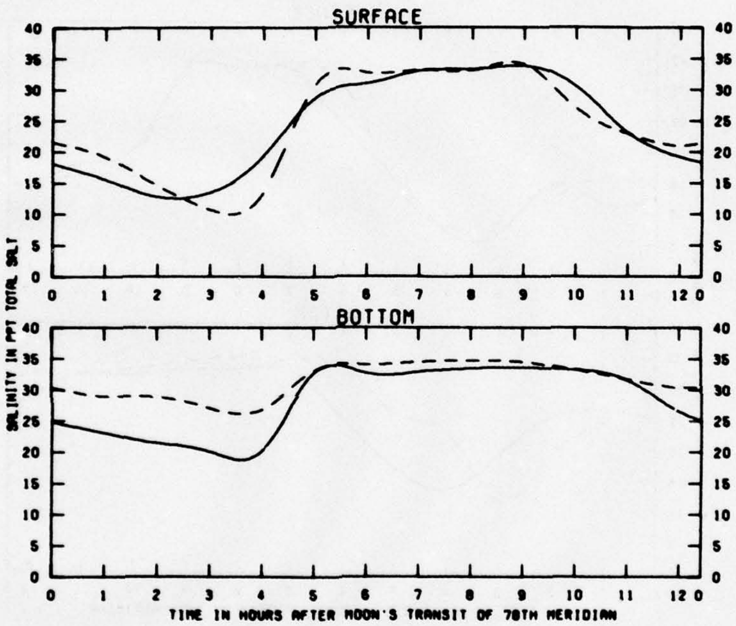
——— PROTOTYPE

– – – – MODEL

VERIFICATION
OF SALINITIES

STATION
5A AND 5C

PLATE 32




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— PROTOTYPE

– – – – MODEL

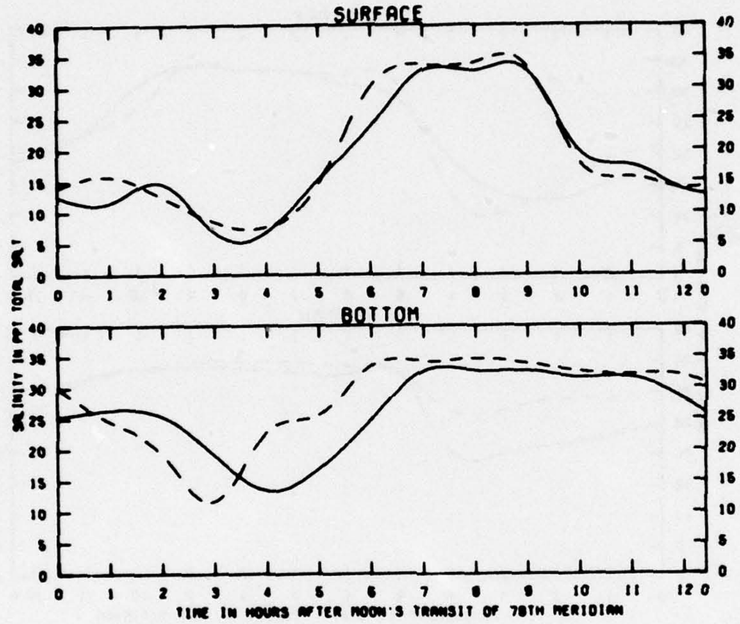
VERIFICATION OF SALINITIES

STATION 5B

AD-A049 639 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 8/3
IMPROVEMENTS FOR LITTLE RIVER INLET SOUTH CAROLINA. HYDRAULIC M--ETC(U)
NOV 77 W C SEABERGH, E F LANE
UNCLASSIFIED WES-TR-H-77-21 NL

3 OF 4

ADA049 639




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

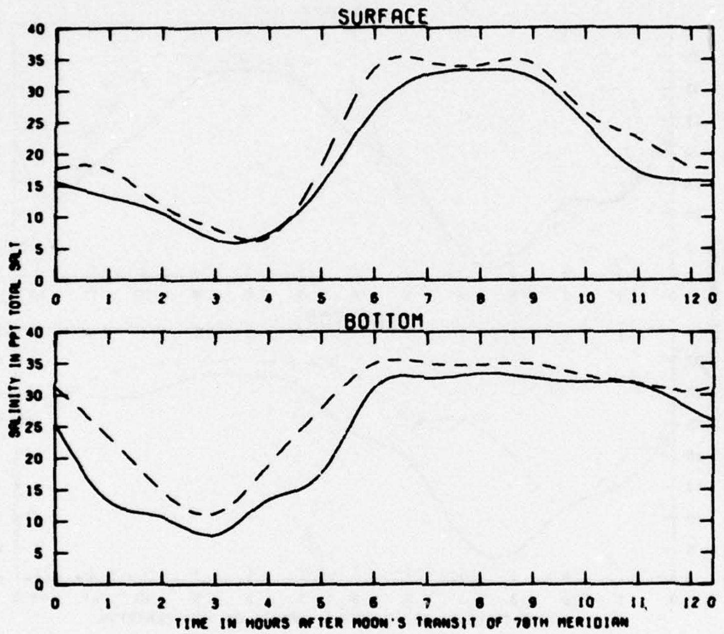
LEGEND

——— PROTOTYPE

– – – – MODEL

VERIFICATION OF SALINITIES

STATION 6A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

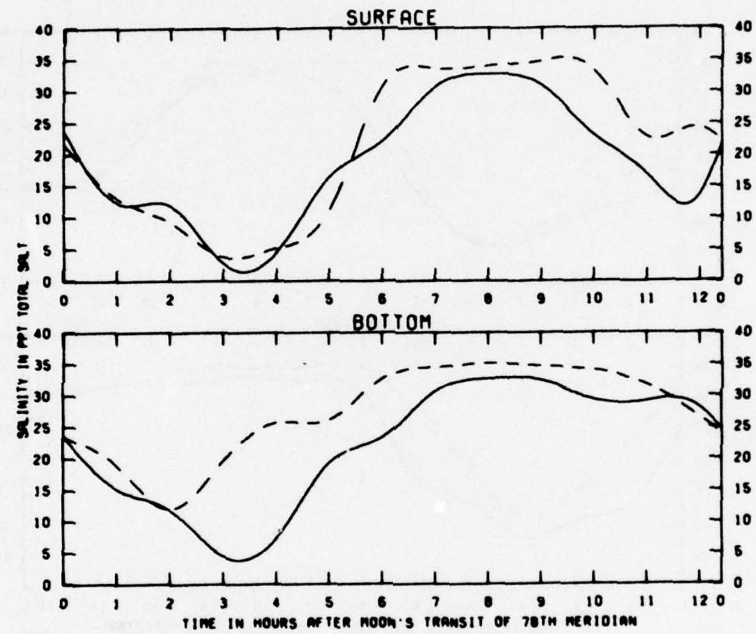
LEGEND

——— PROTOTYPE

– – – – MODEL

VERIFICATION
OF SALINITIES

STATION
6B




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

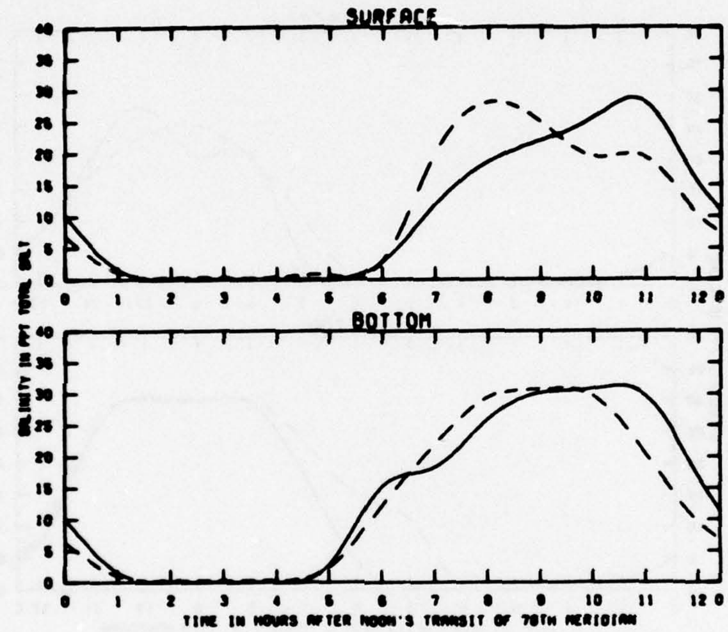
LEGEND

——— PROTOTYPE

– – – – MODEL

VERIFICATION
OF SALINITIES

STATION
6C




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

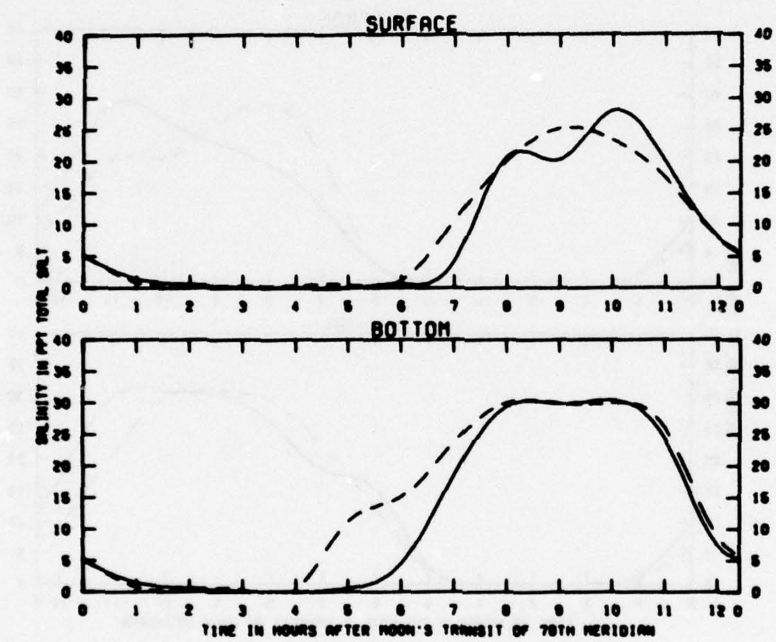
LEGEND

——— PHOTOTYPE

– – – – MODEL

VERIFICATION OF SALINITIES

STATION 7A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

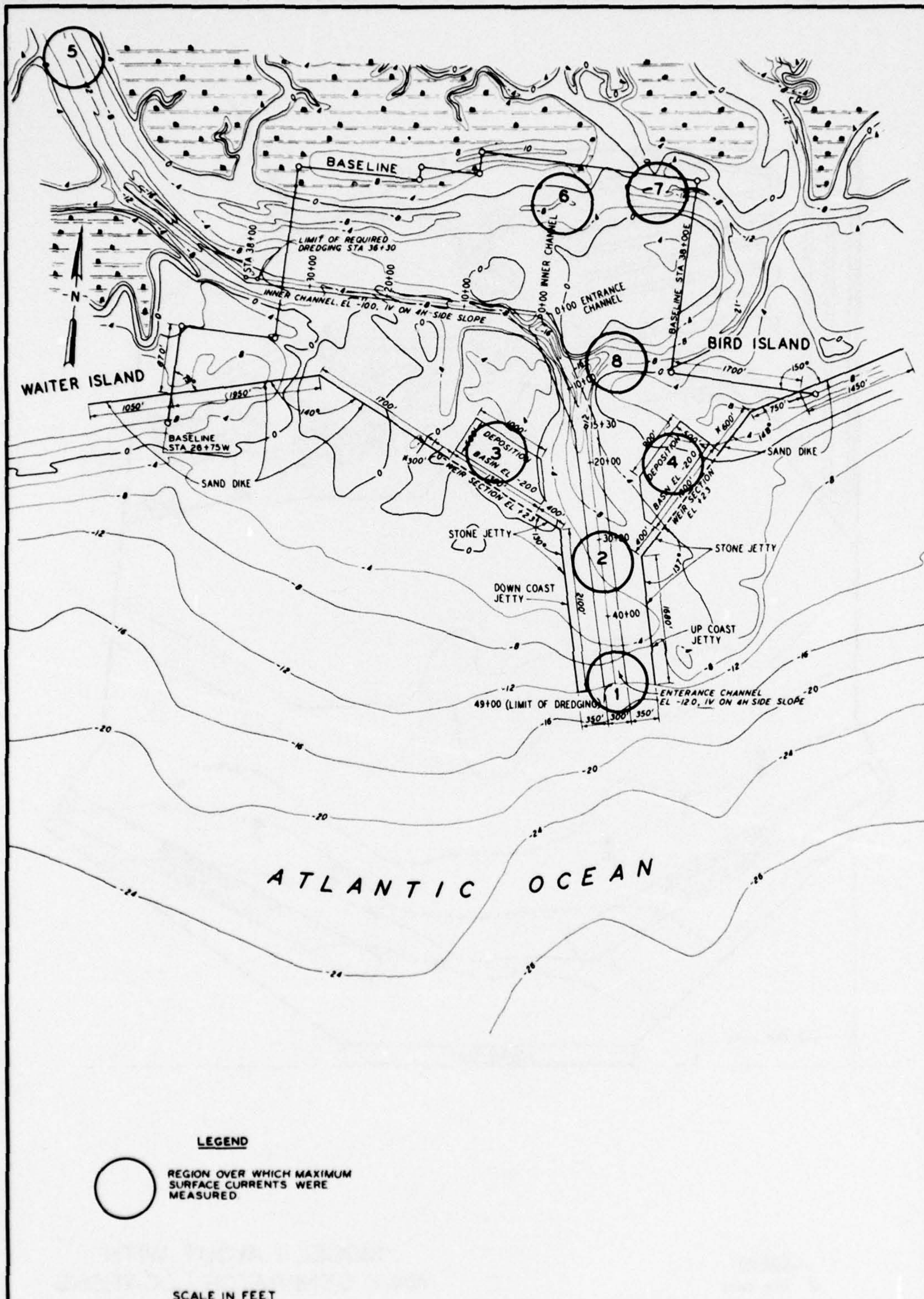
LEGEND

——— PROTOTYPE

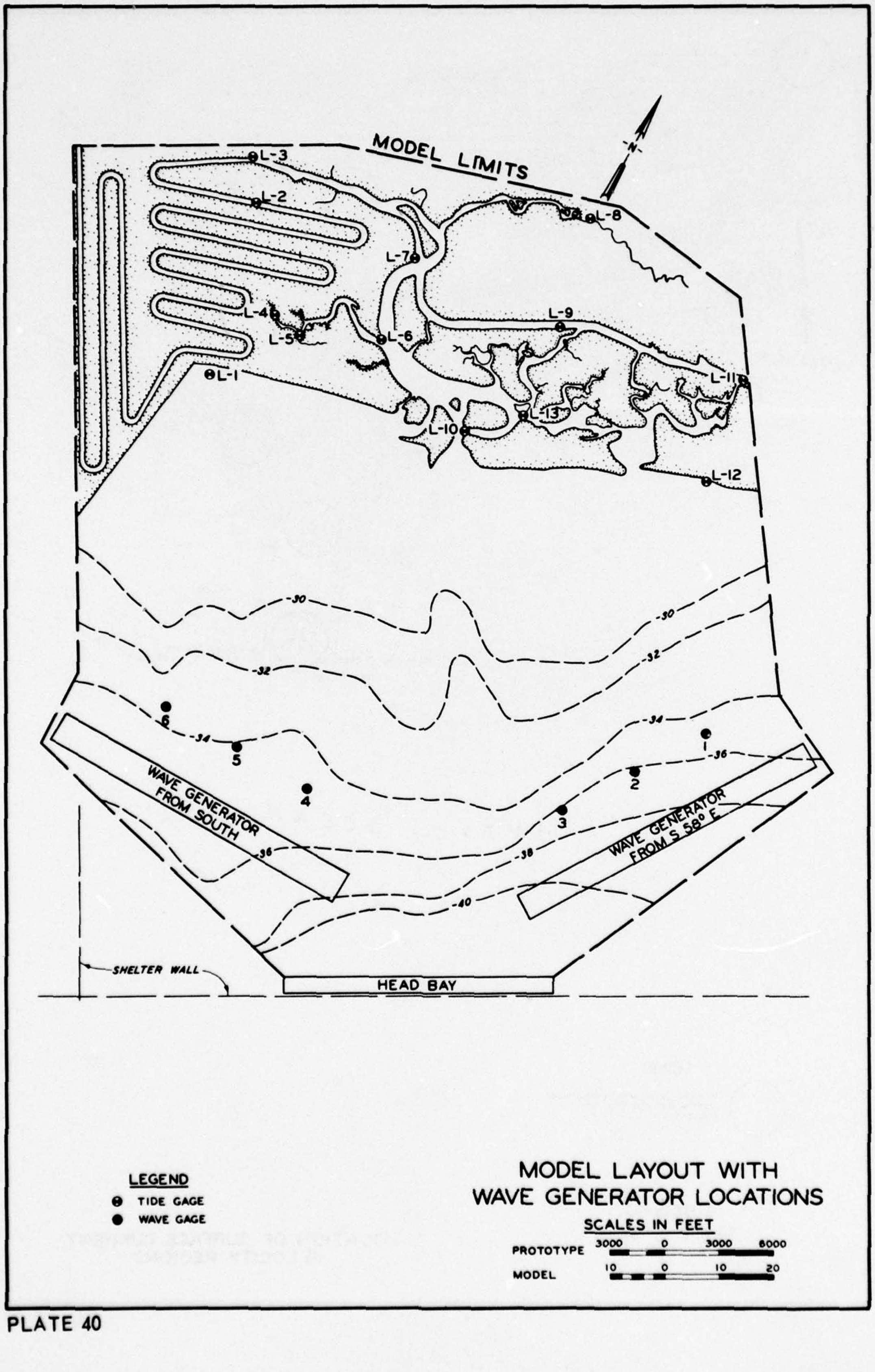
– – – – MODEL

VERIFICATION OF SALINITIES

STATION 7B

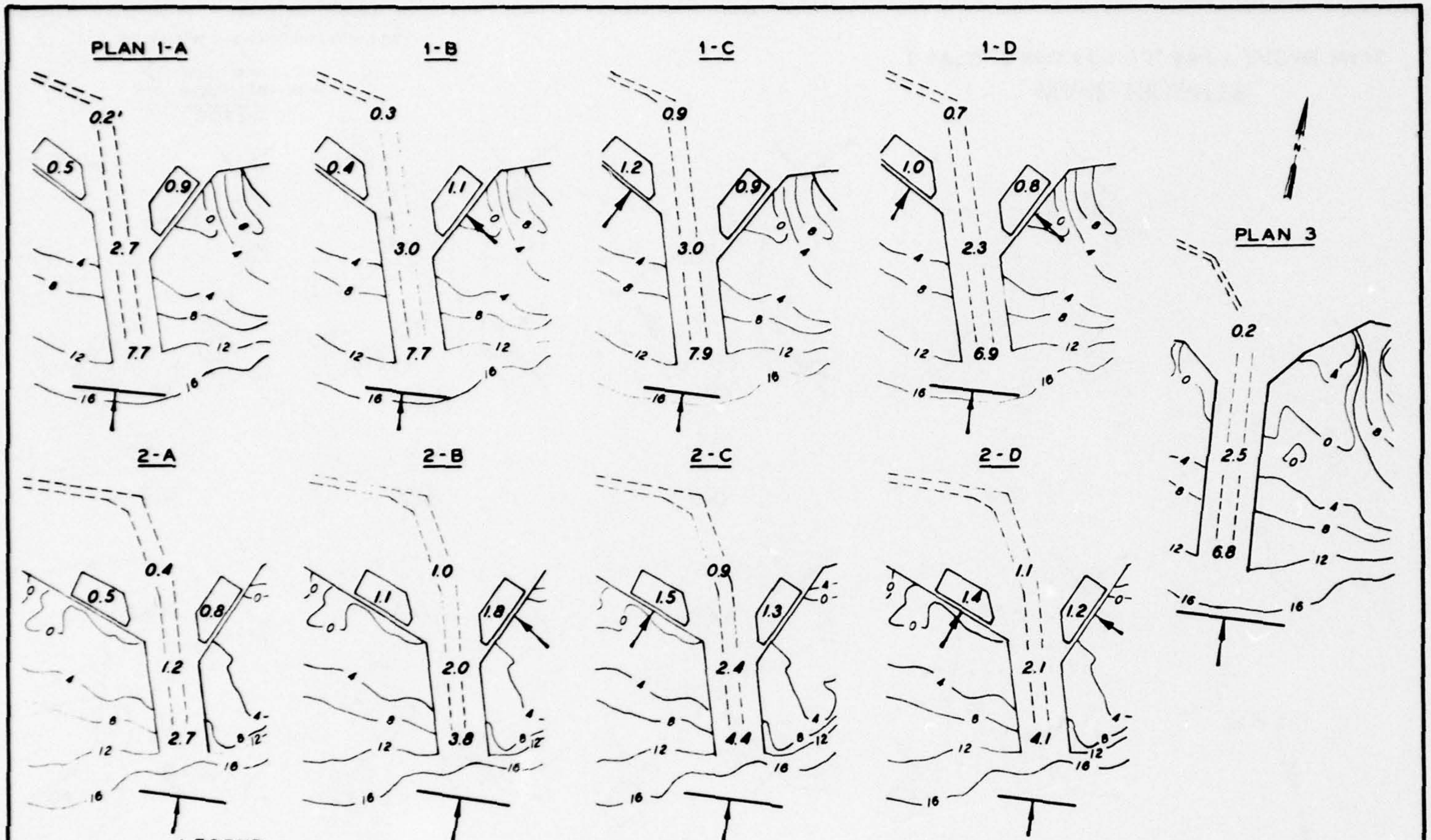



LOCATION OF SURFACE CURRENT
VELOCITY REGIONS




MODEL LAYOUT WITH WAVE GENERATOR LOCATIONS

PLATE 40




LEGEND

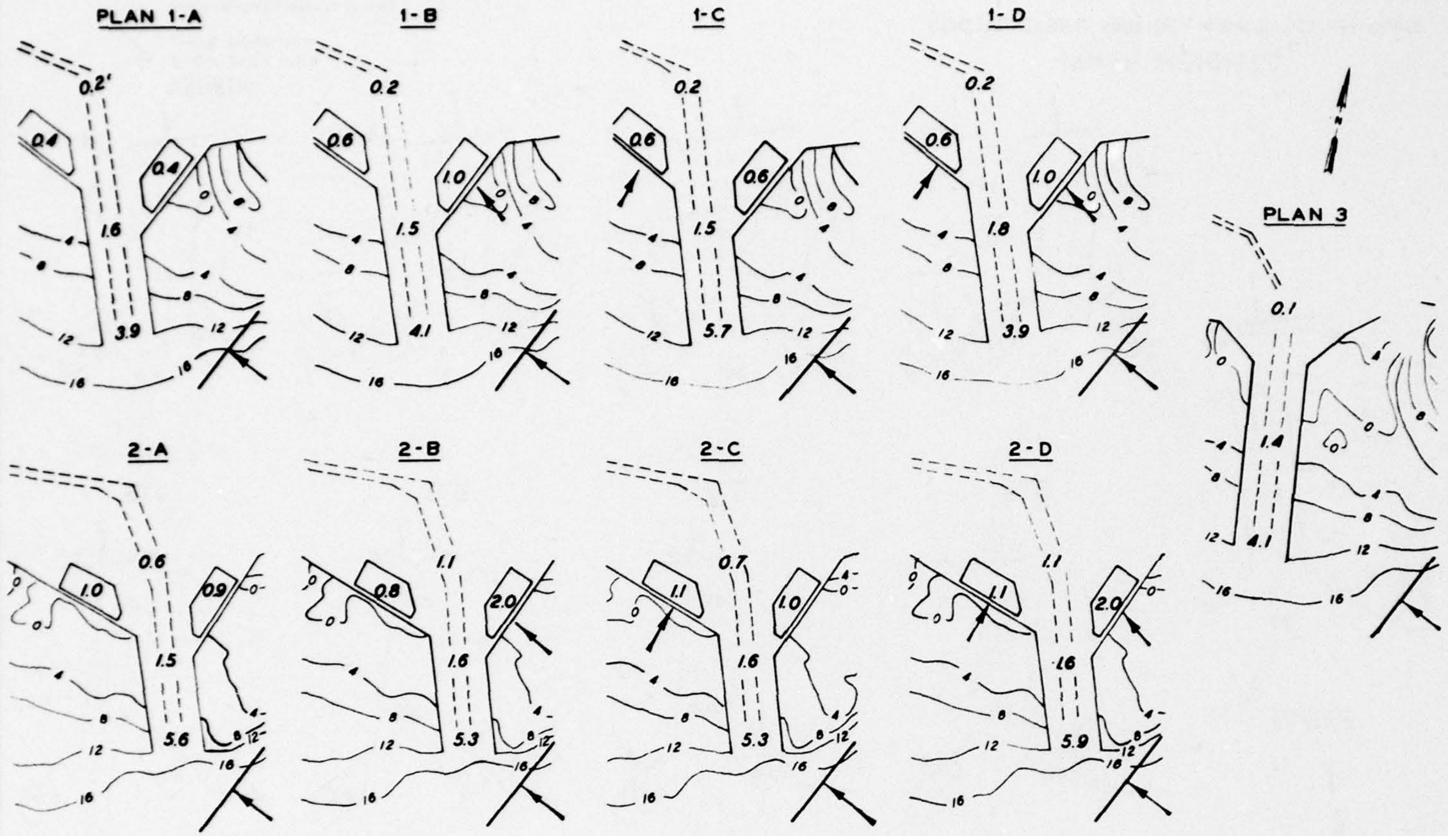
FLOW OVER WEIR

WAVE DIRECTION

NOTE WAVE HEIGHTS GIVEN IN FEET

WAVE HEIGHTS

SOUTH, 7-SEC PERIOD, 4.6-FT OCEAN WAVE



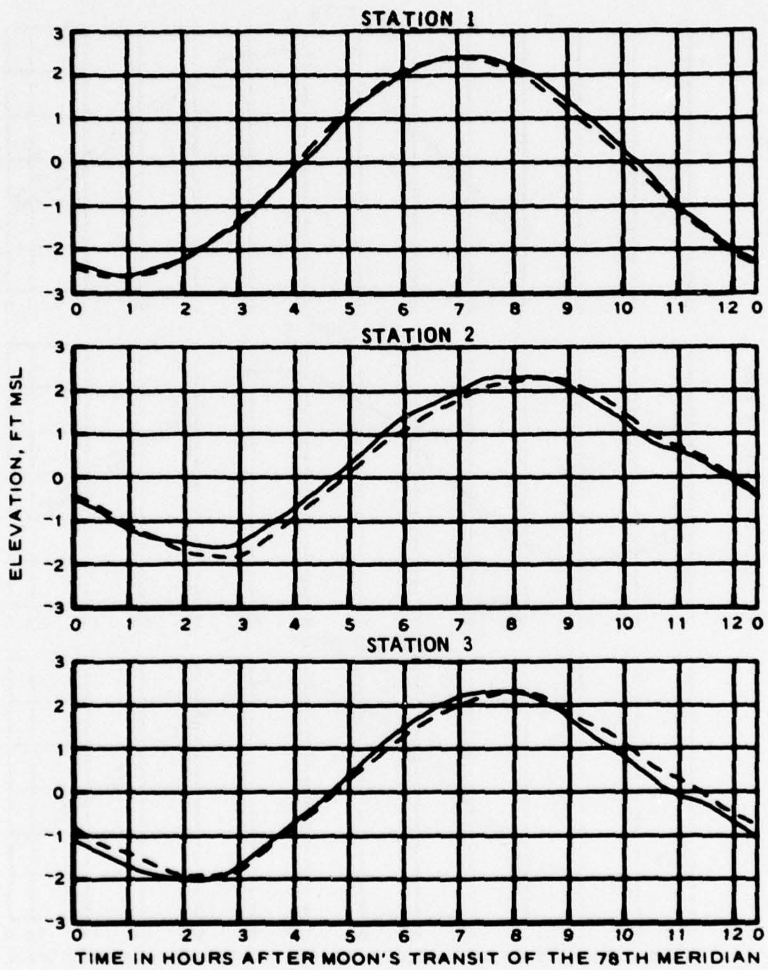

## LEGEND

FLOW OVER WEIR
WAVE DIRECTION

NOTE: WAVE HEIGHTS GIVEN IN FEET.

## WAVE HEIGHTS

S 58° E, 7-SEC PERIOD, 4.8-FT OCEAN WAVE




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

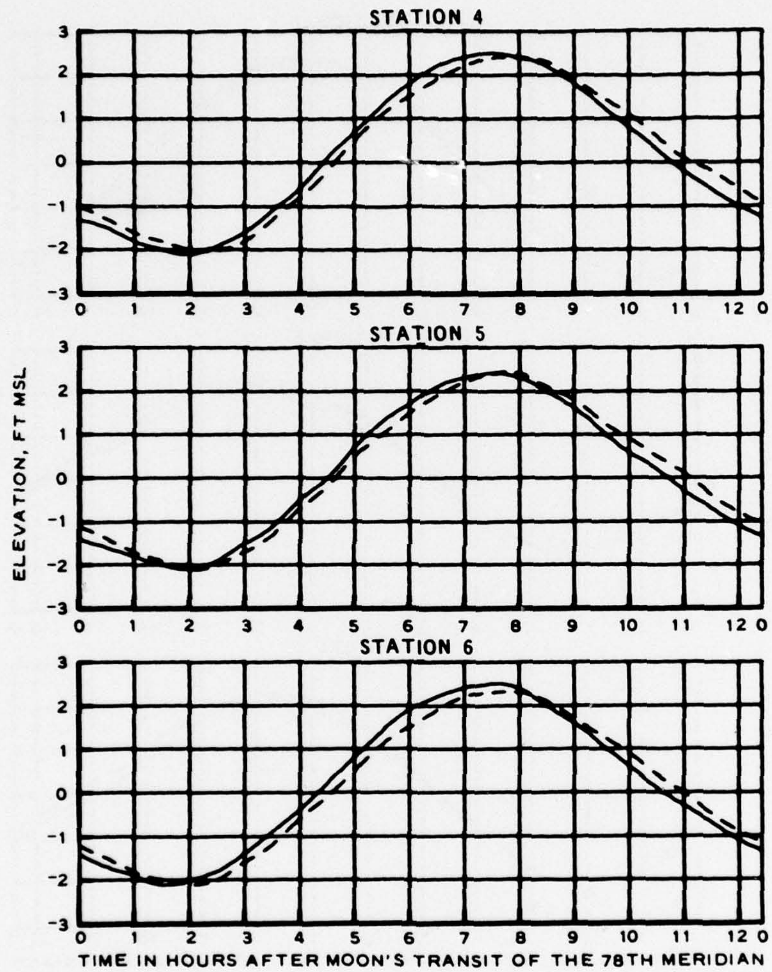
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D ON TIDAL HEIGHTS

STATIONS 1, 2, AND 3




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

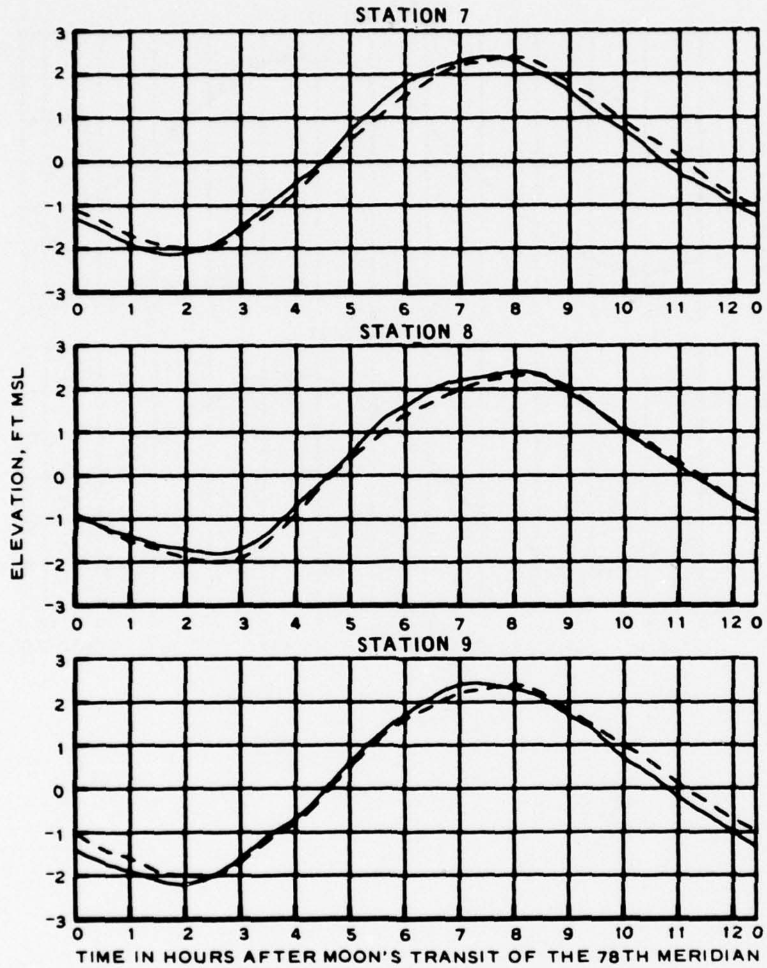
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D ON TIDAL HEIGHTS

STATIONS 4, 5, AND 6




TEST CONDITIONS

OCEAN TIDE RANGE ≈ 5.0 FT

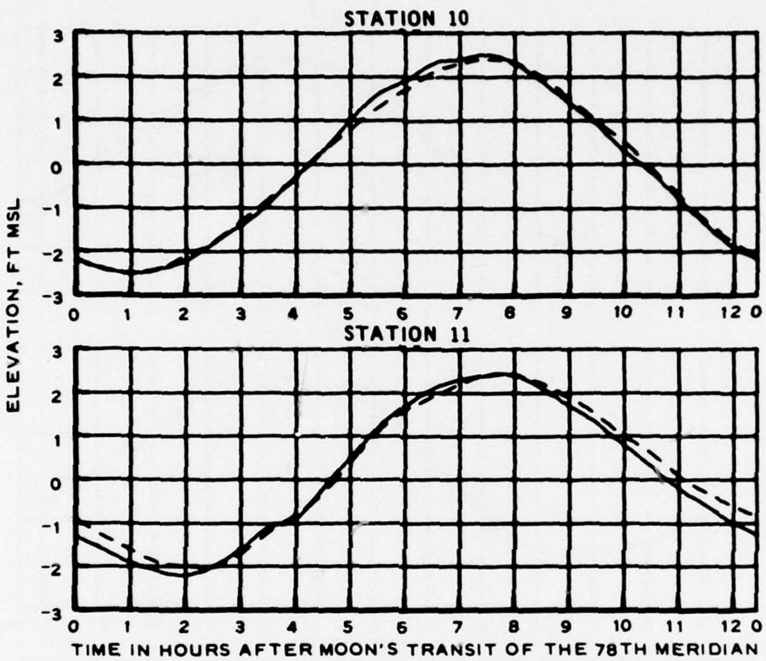
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D ON TIDAL HEIGHTS

STATIONS 7, 8, AND 9




TEST CONDITIONS

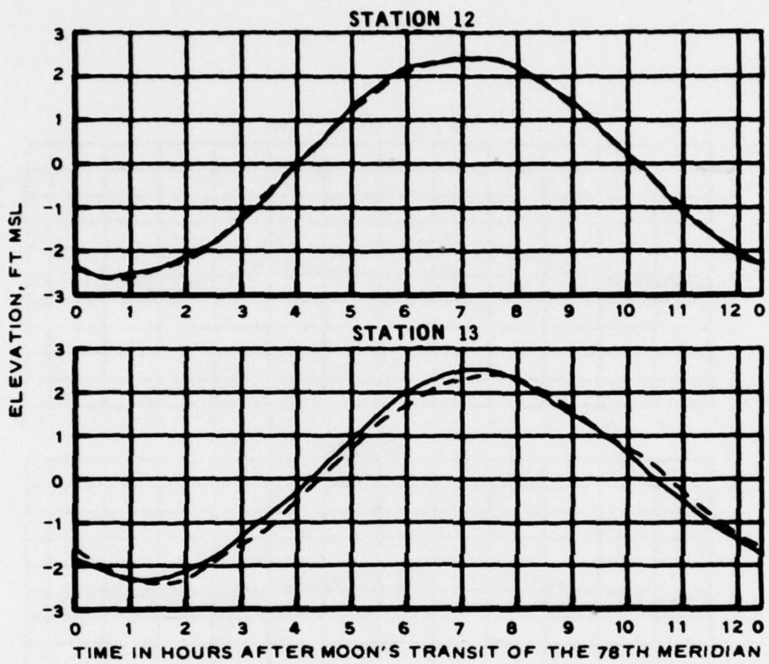
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON TIDAL HEIGHTS
STATIONS
10 AND 11




*TEST CONDITIONS*

OCEAN TIDE RANGE = 5.0 FT

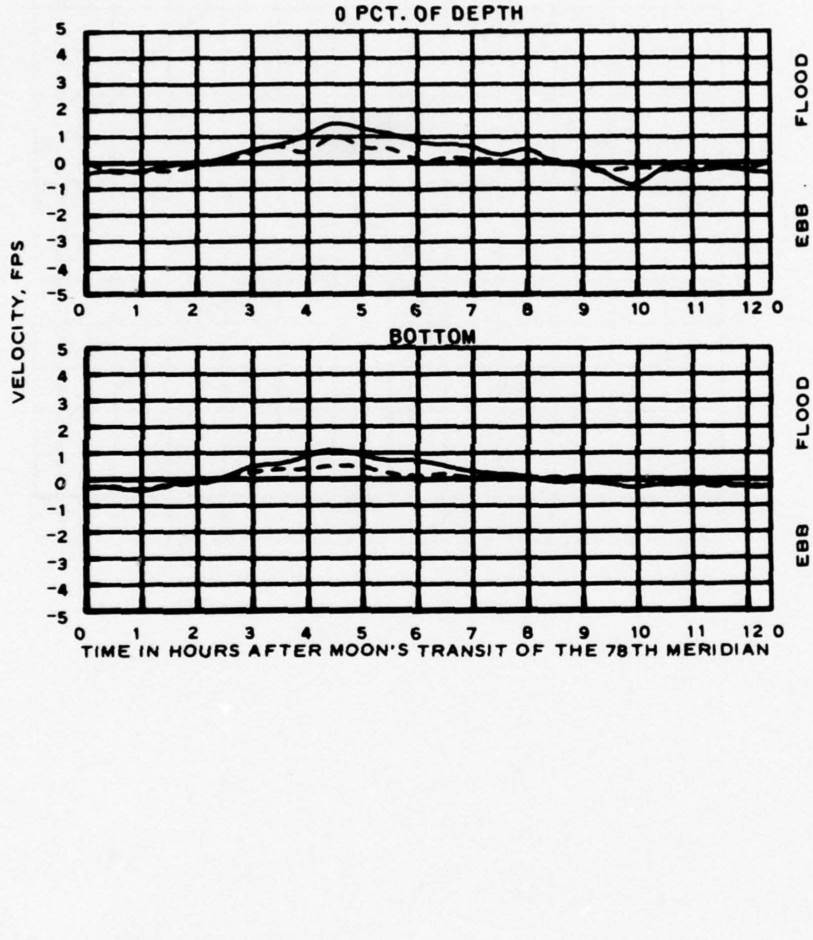
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON TIDAL HEIGHTS

STATIONS
12 AND 13




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

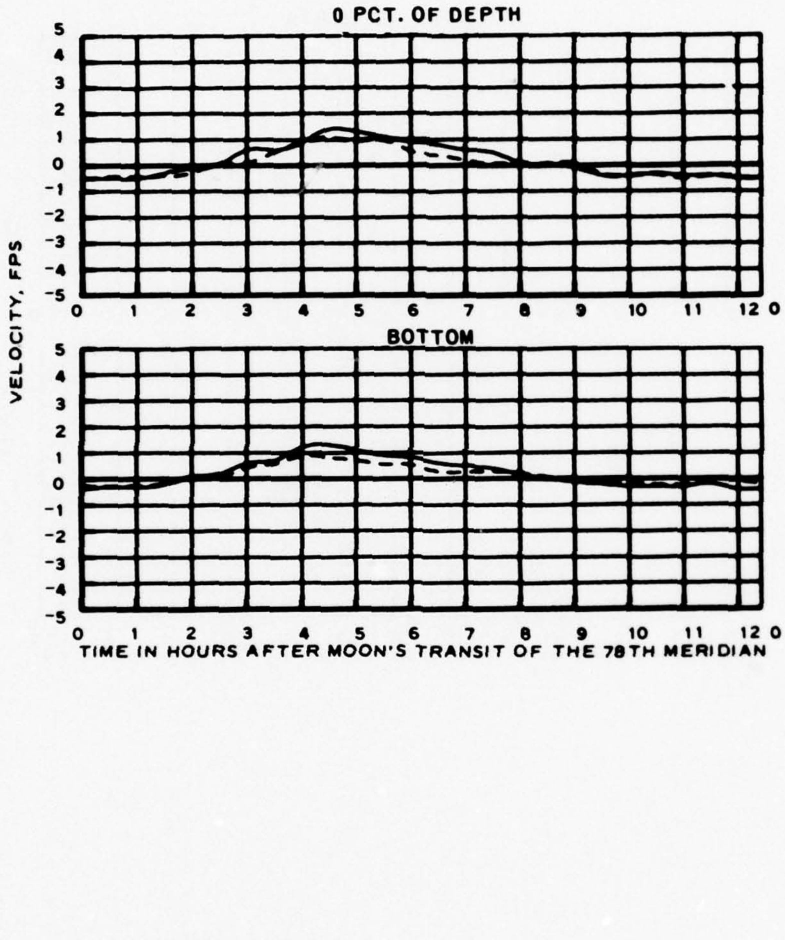
LEGEND

——— BASE

- - - - PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
1A




TEST CONDITIONS

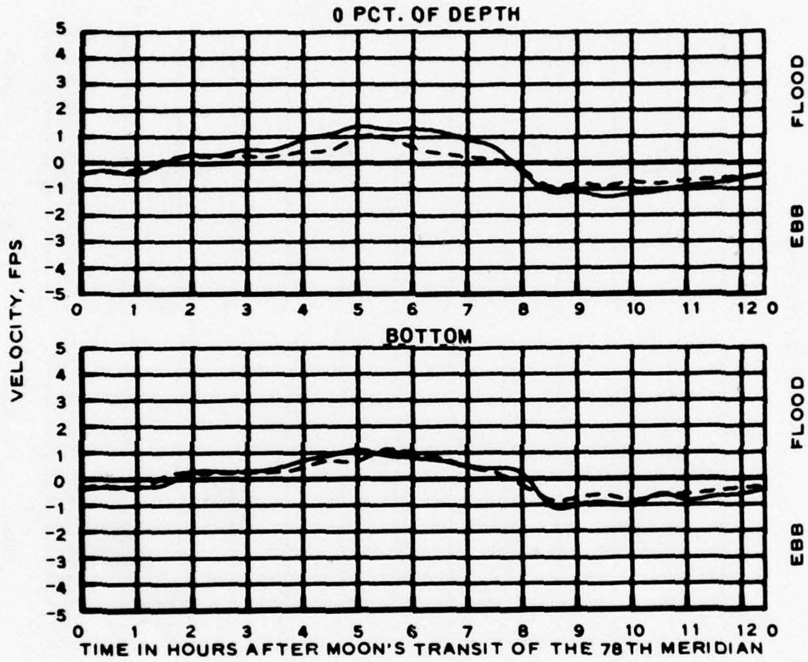
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
1B




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

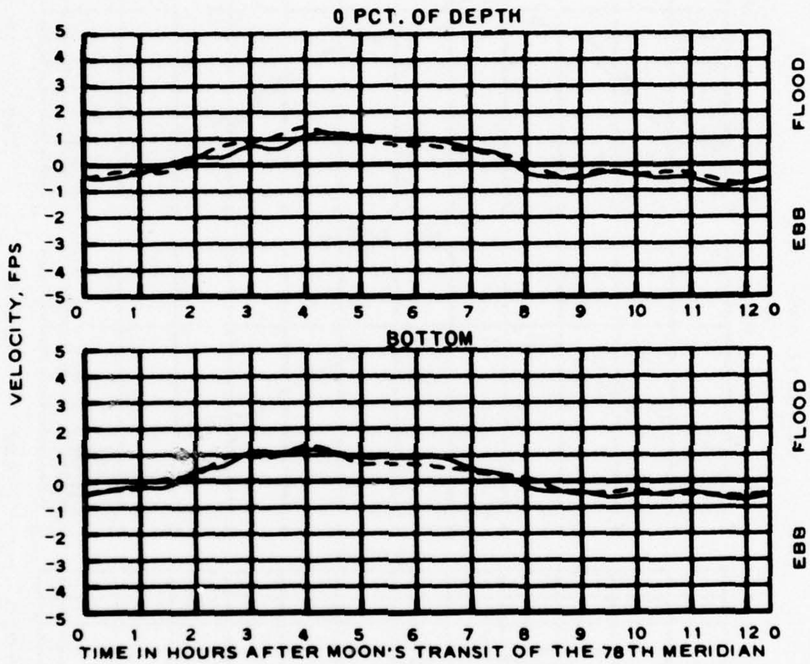
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
2A




TEST CONDITIONS

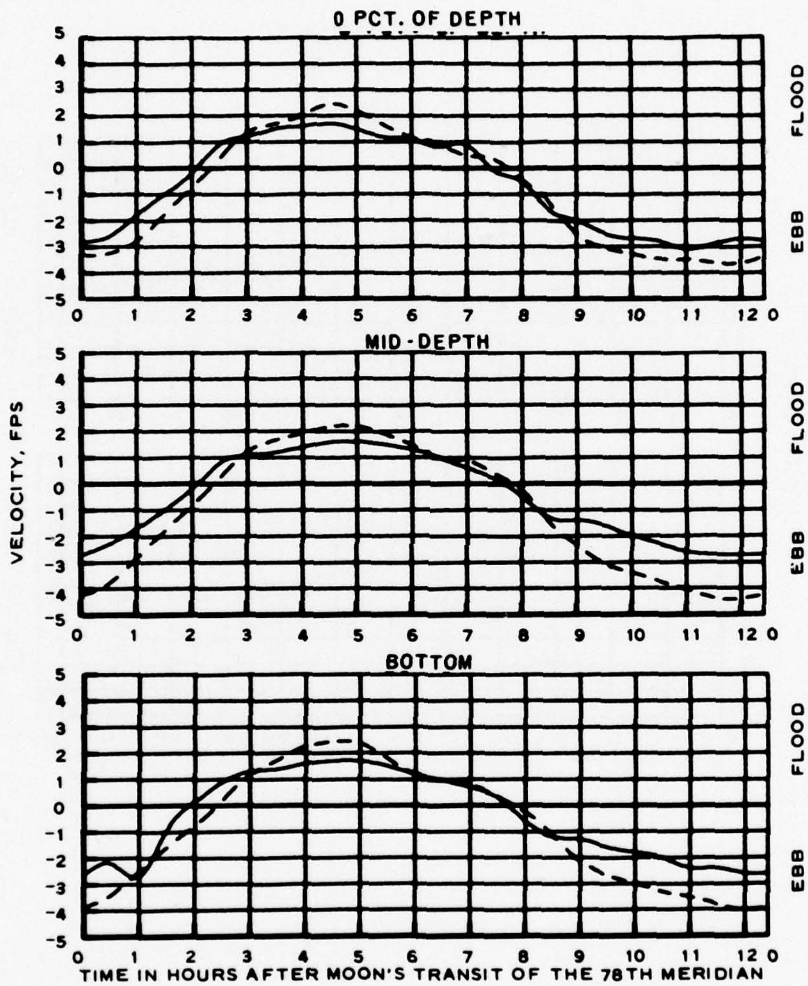
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
2B




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

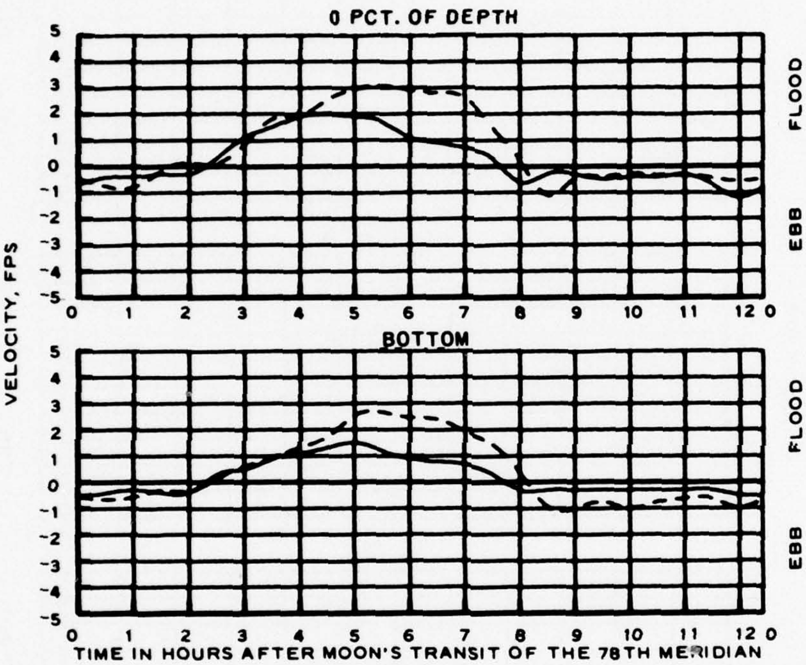
**LEGEND**

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
3A



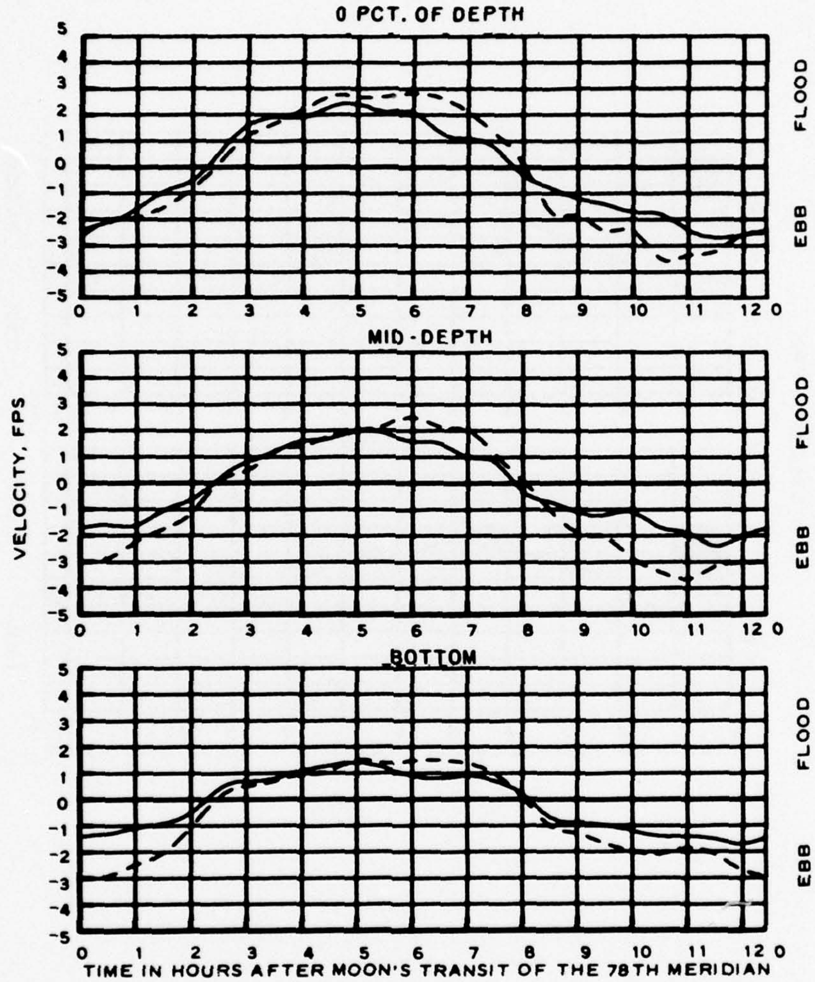

TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE
– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
3B




<u>TEST CONDITIONS</u>

OCEAN TIDE RANGE = 5.0 FT

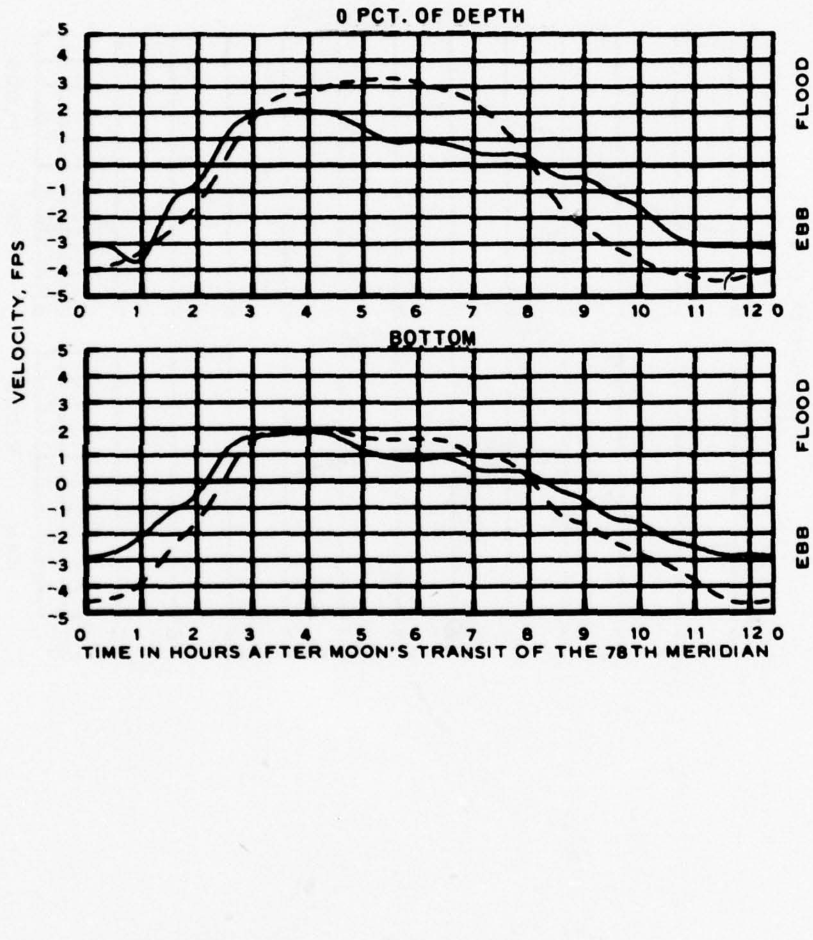
<u>LEGEND</u>

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
3C




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

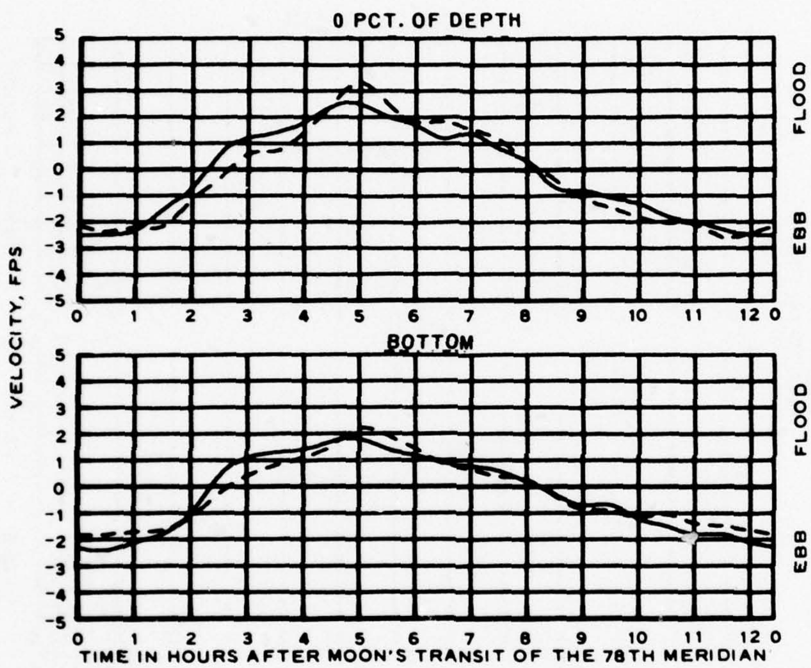
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
4A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

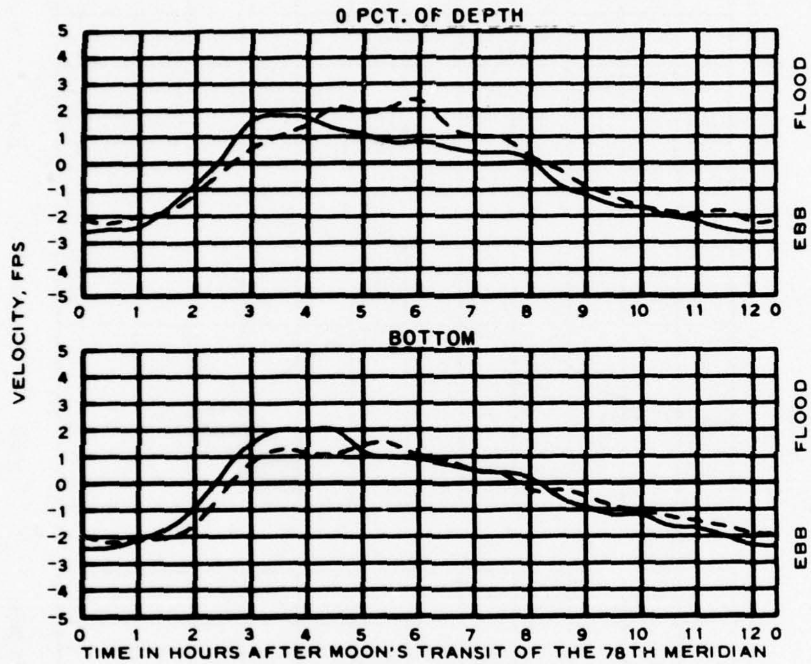
LEGEND

——— BASE

- - - - PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
4B




TEST CONDITIONS

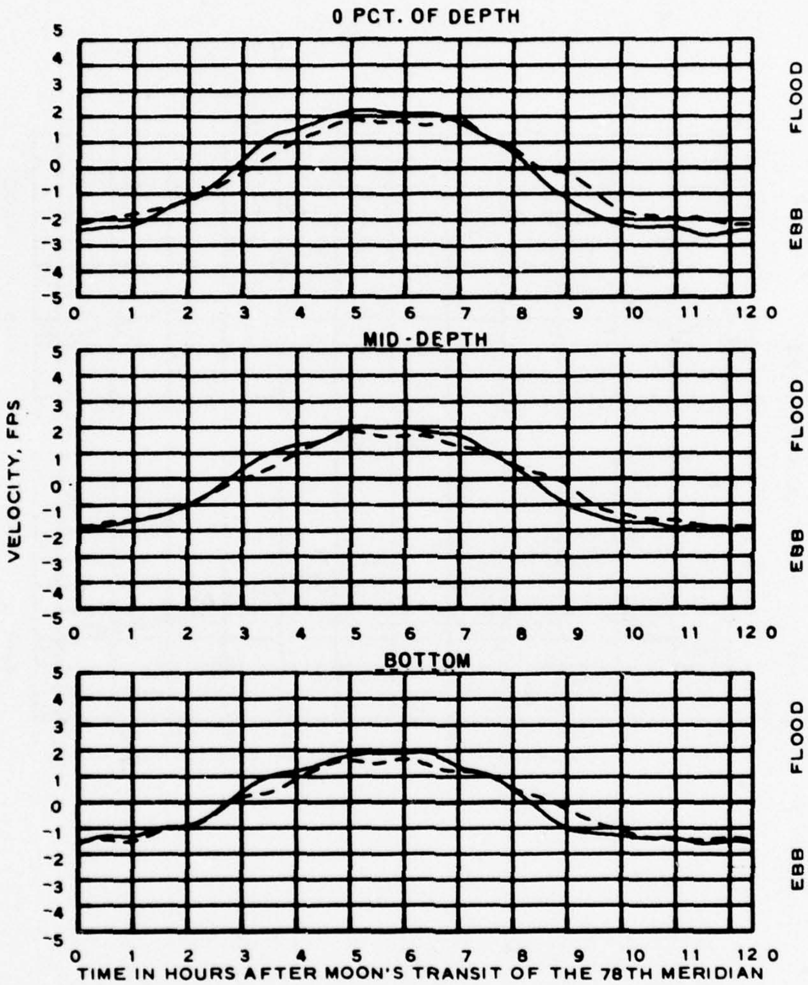
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
4C




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

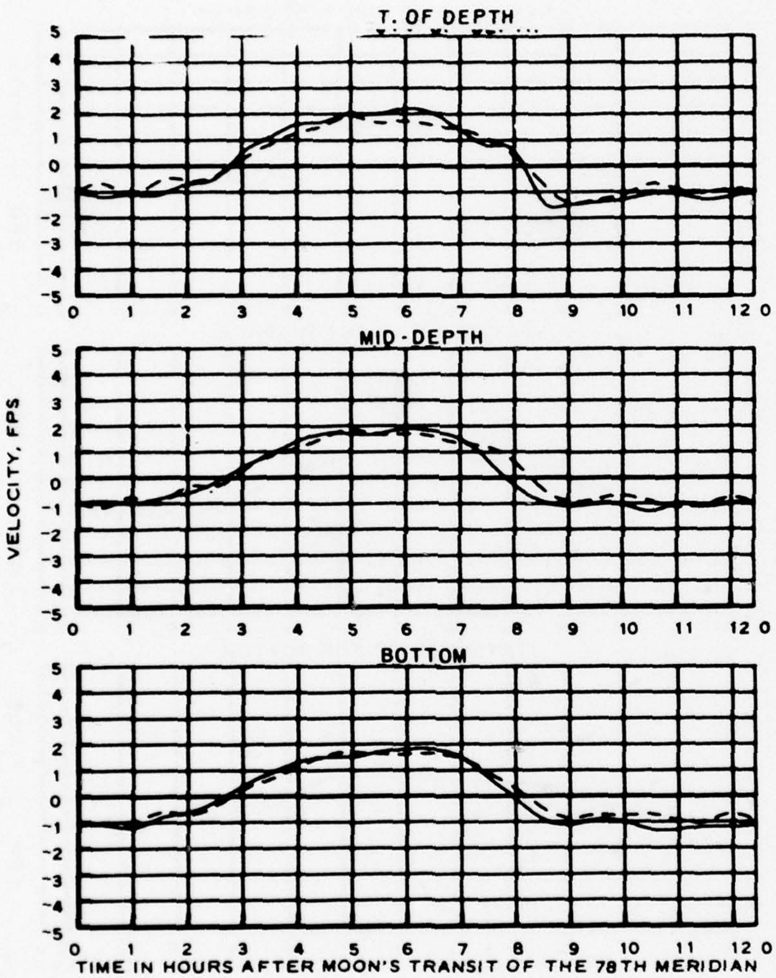
LEGEND

———— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
5B




TEST CONDITIONS

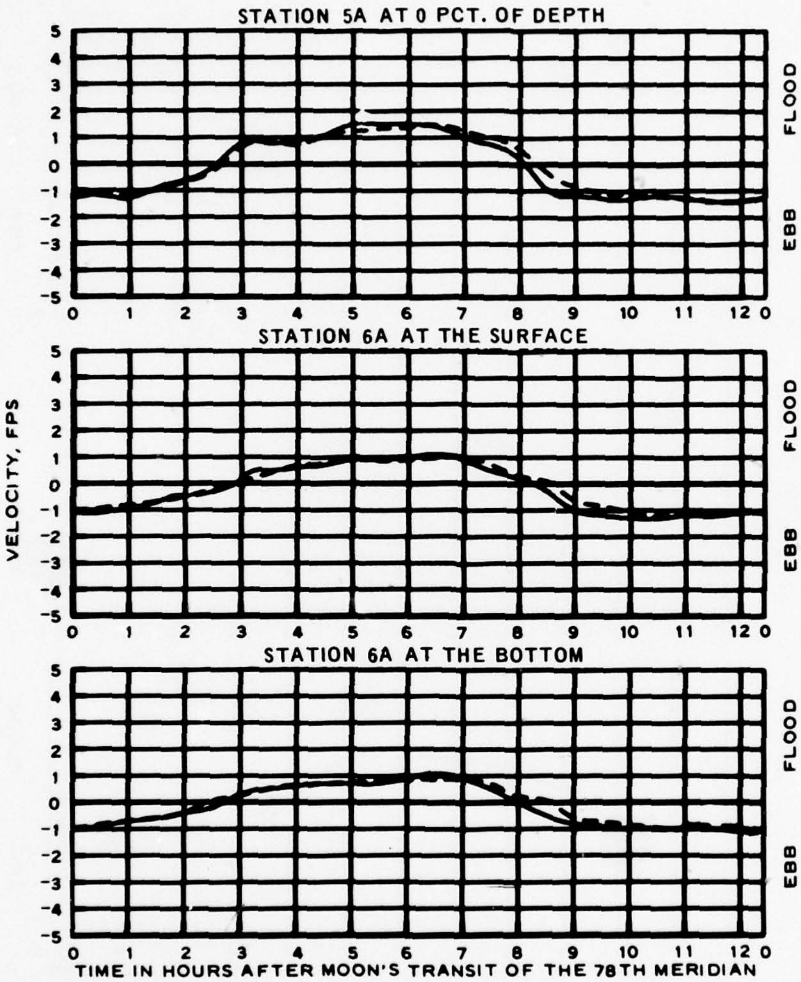
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
5C




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

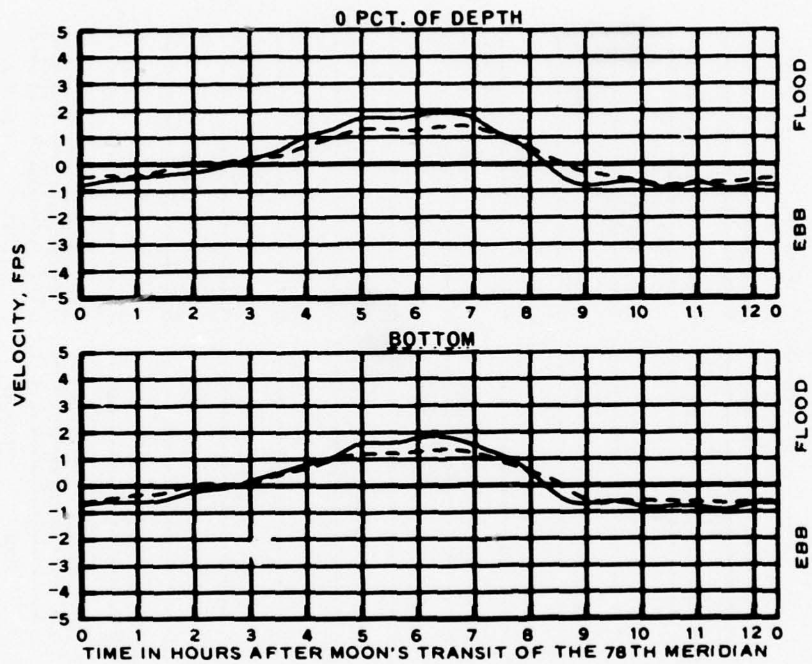
**LEGEND**

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
5A, 6A, AND 6A




TEST CONDITIONS

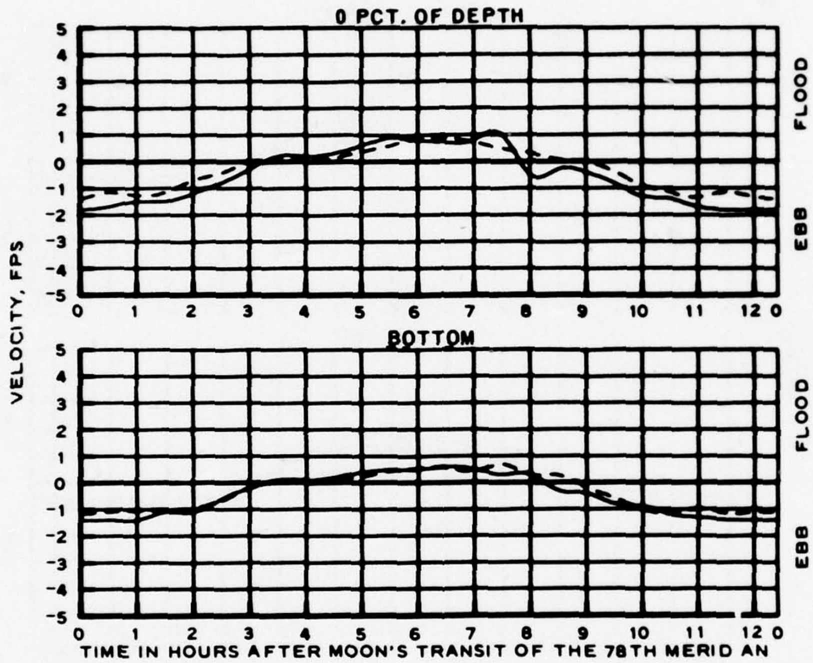
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
6B




TEST CONDITIONS

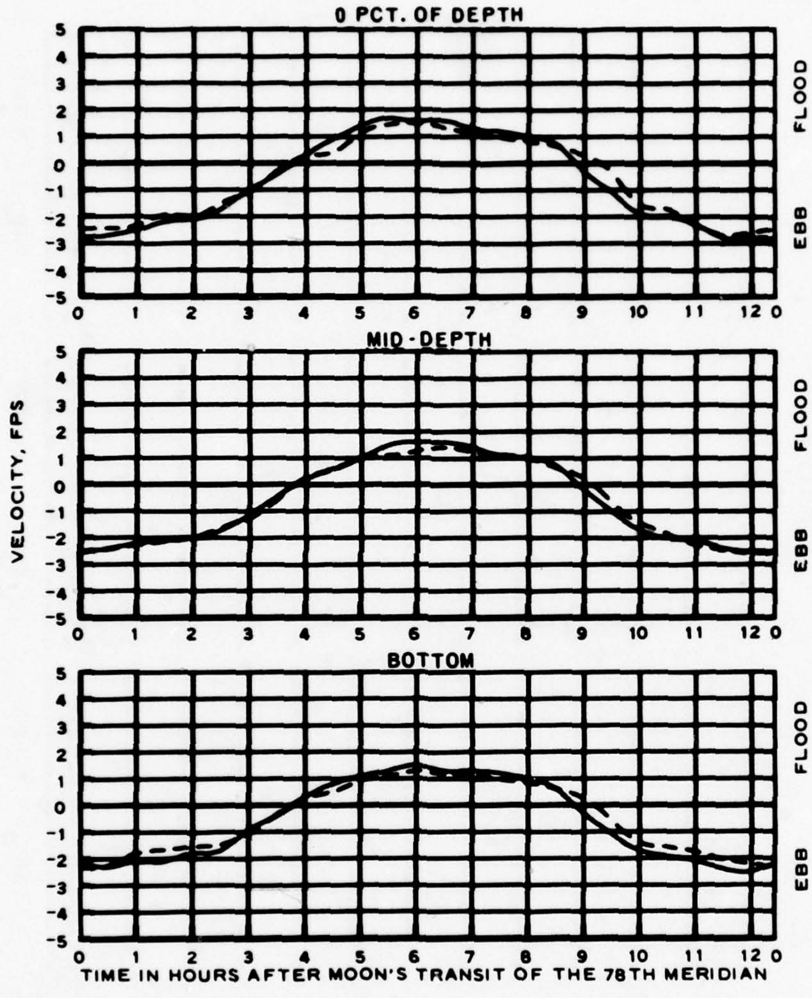
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
6C




TEST CONDITIONS

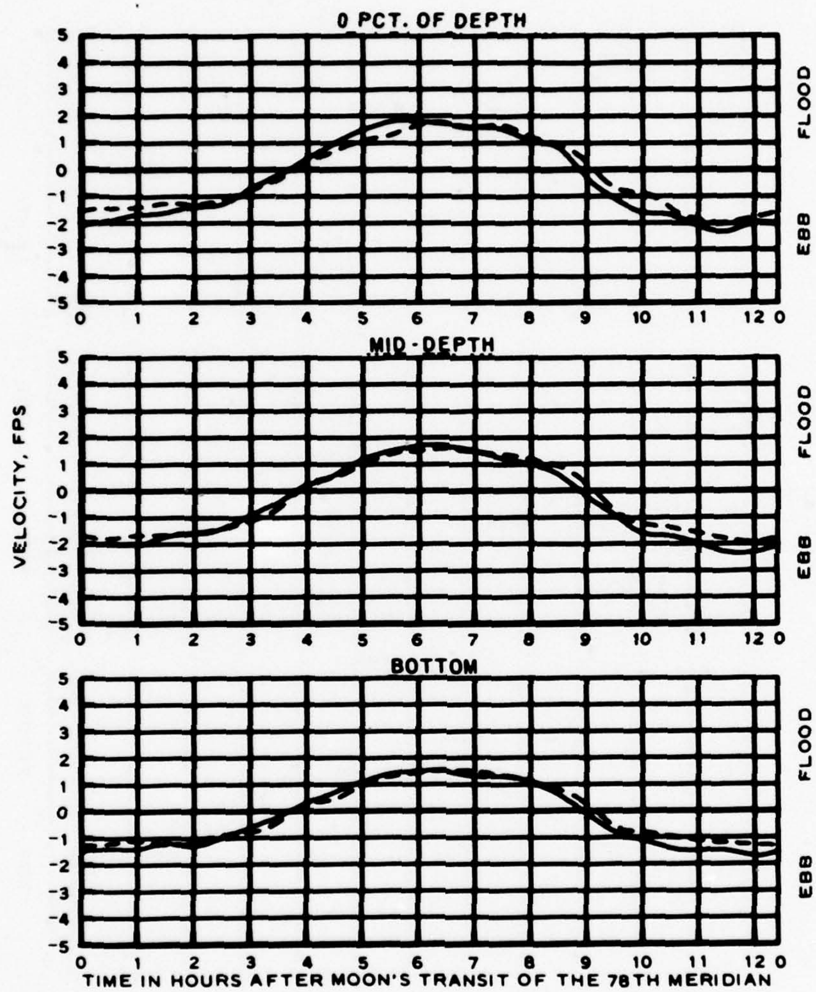
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
7A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

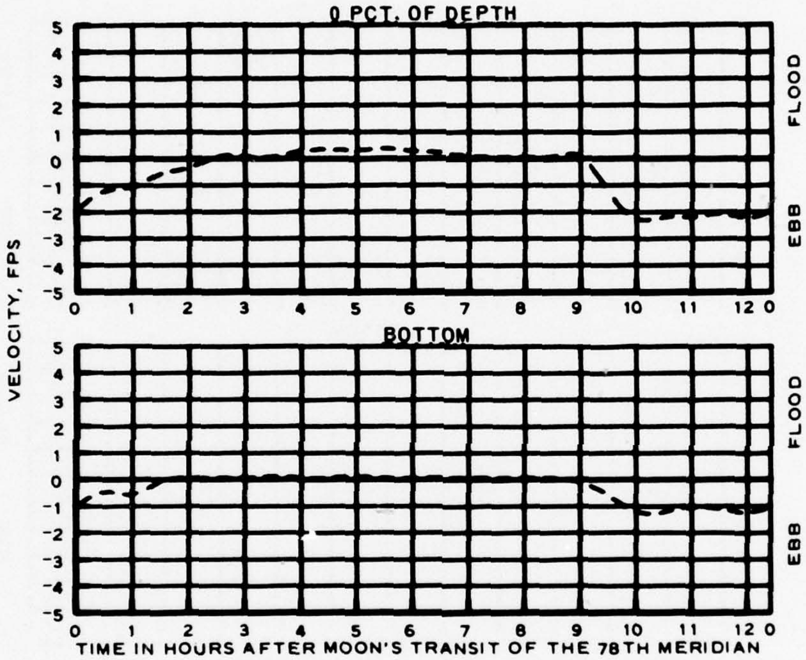
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
7B




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

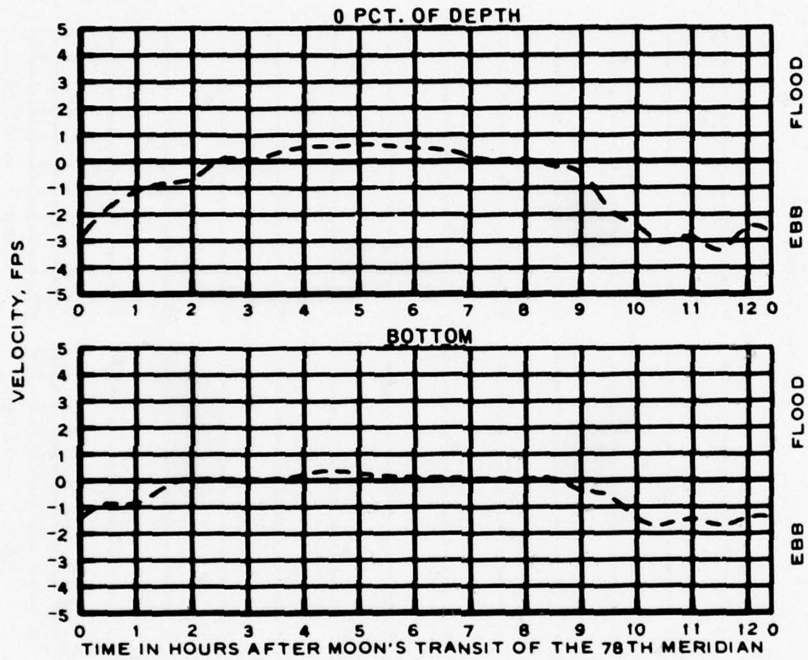
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
8A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

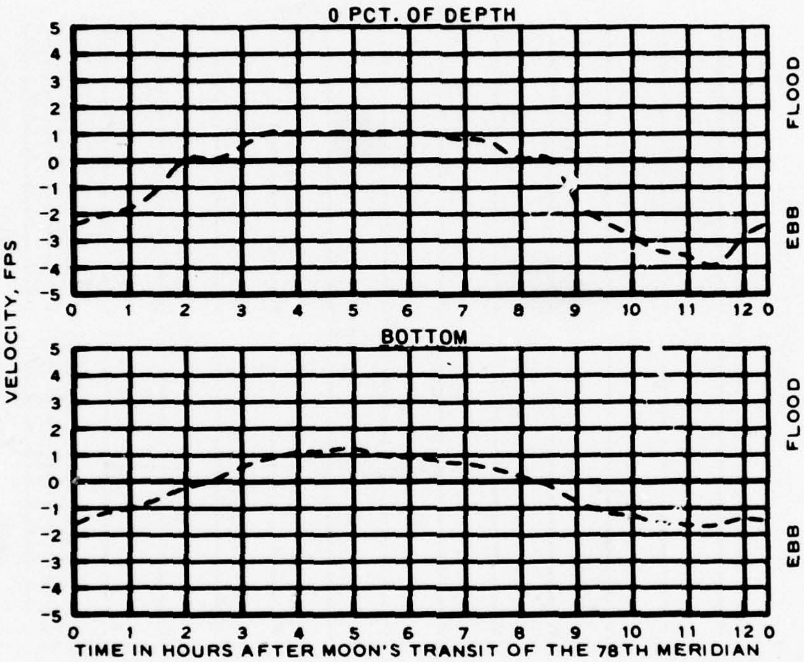
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
9A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

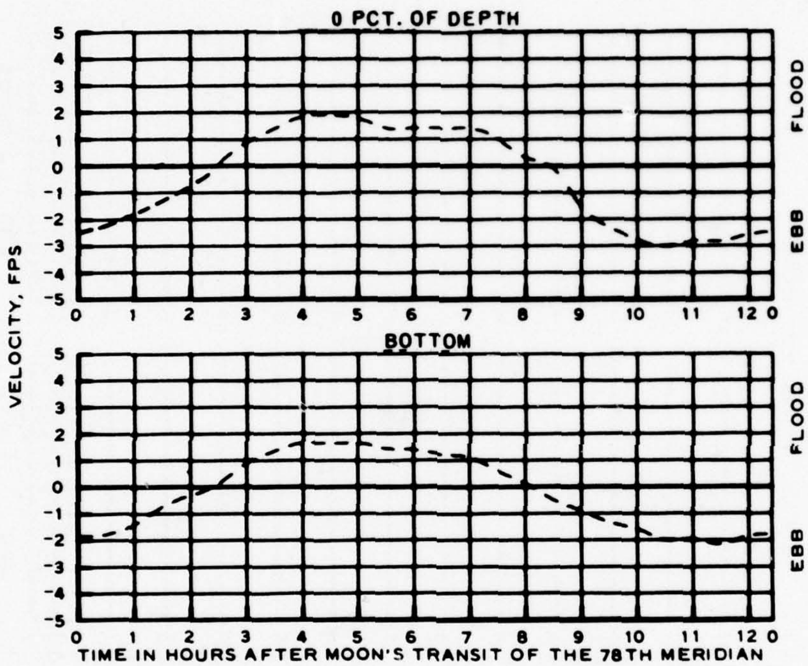
– – – – PLAN 2D

**EFFECTS OF PLAN 2D ON VELOCITIES**

STATION

10A

PLATE 67




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

LEGEND

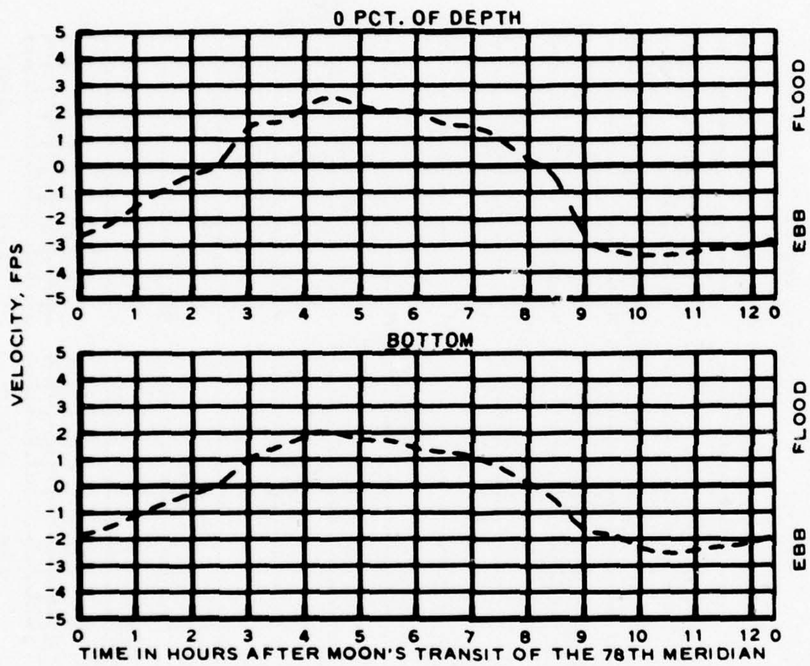
——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D ON VELOCITIES

STATION

11A




TEST CONDITIONS

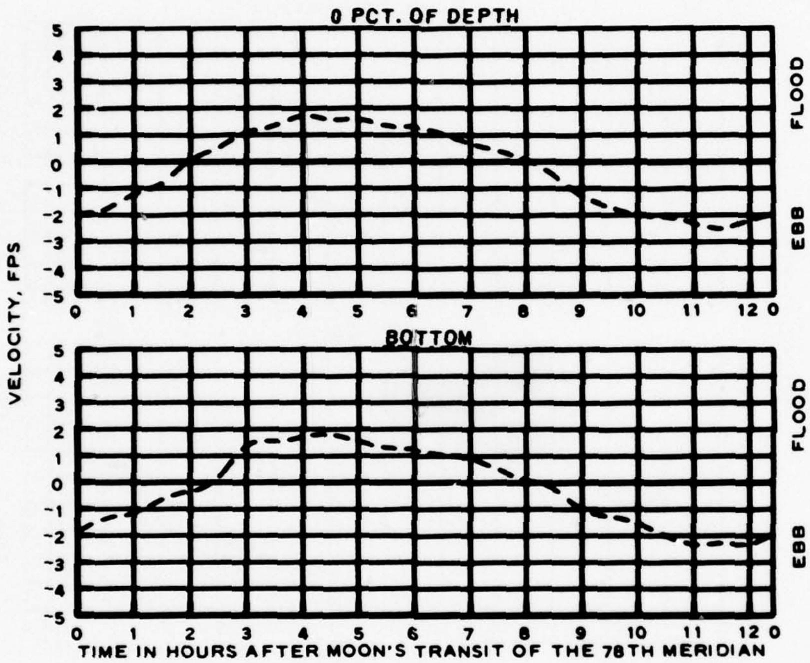
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
12A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

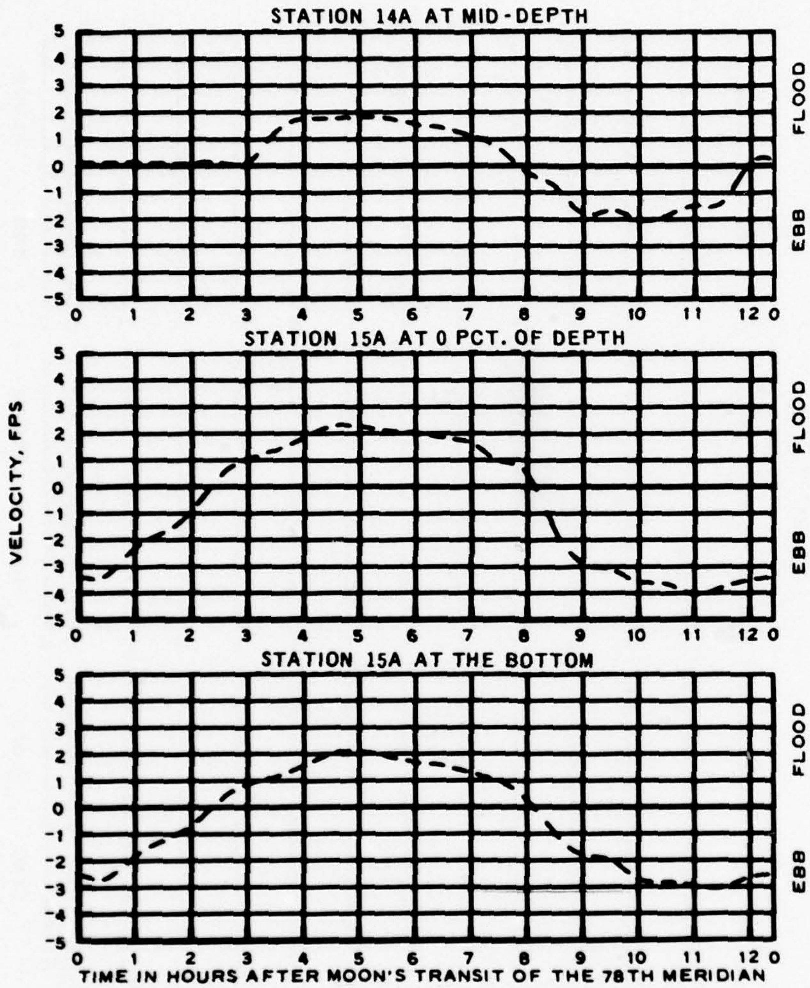
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D ON VELOCITIES

STATION 13A




TEST CONDITIONS

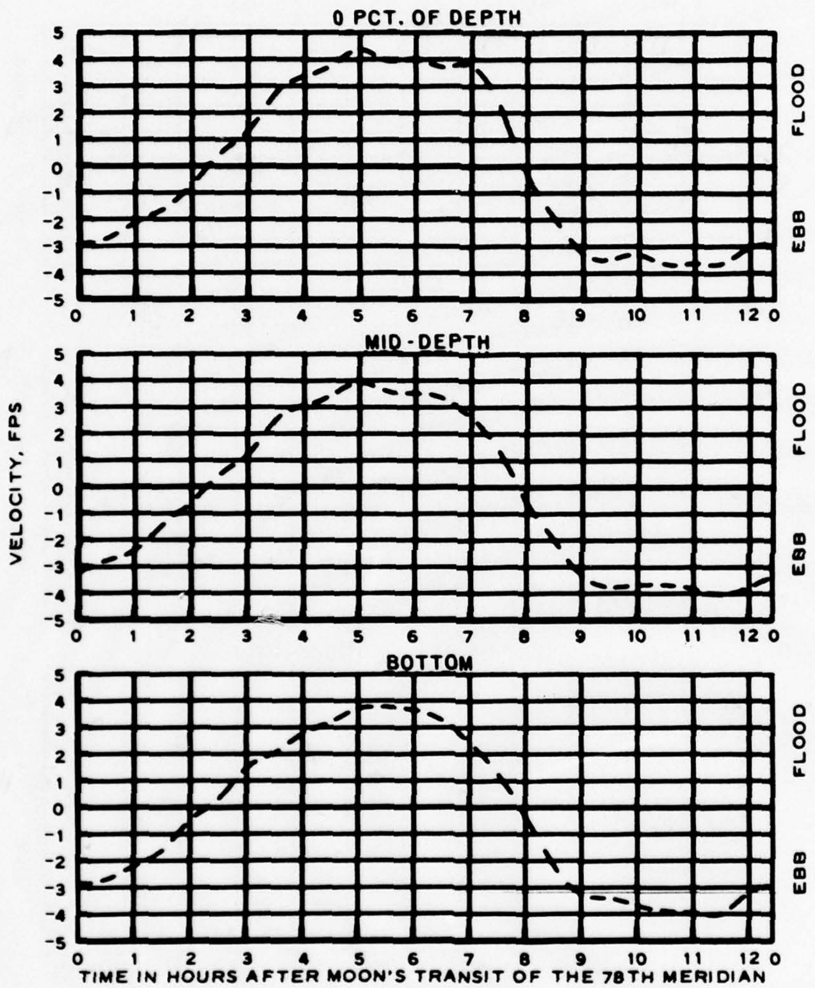
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
14A, 15A, AND 15A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

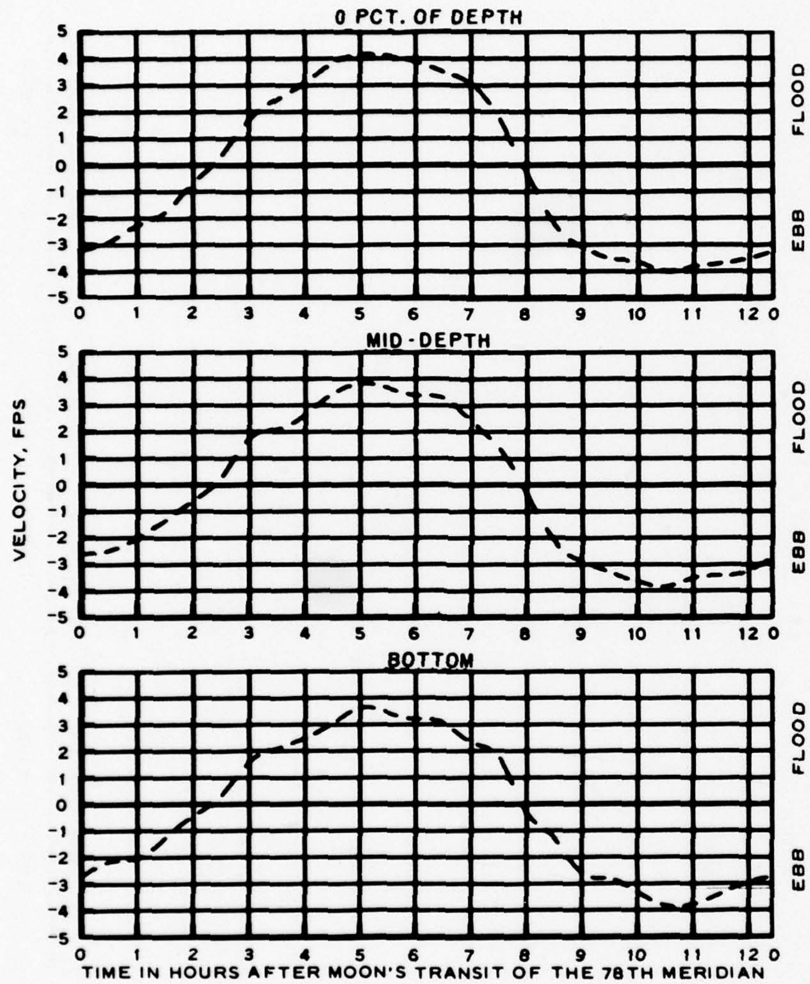
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
16A




TEST CONDITIONS

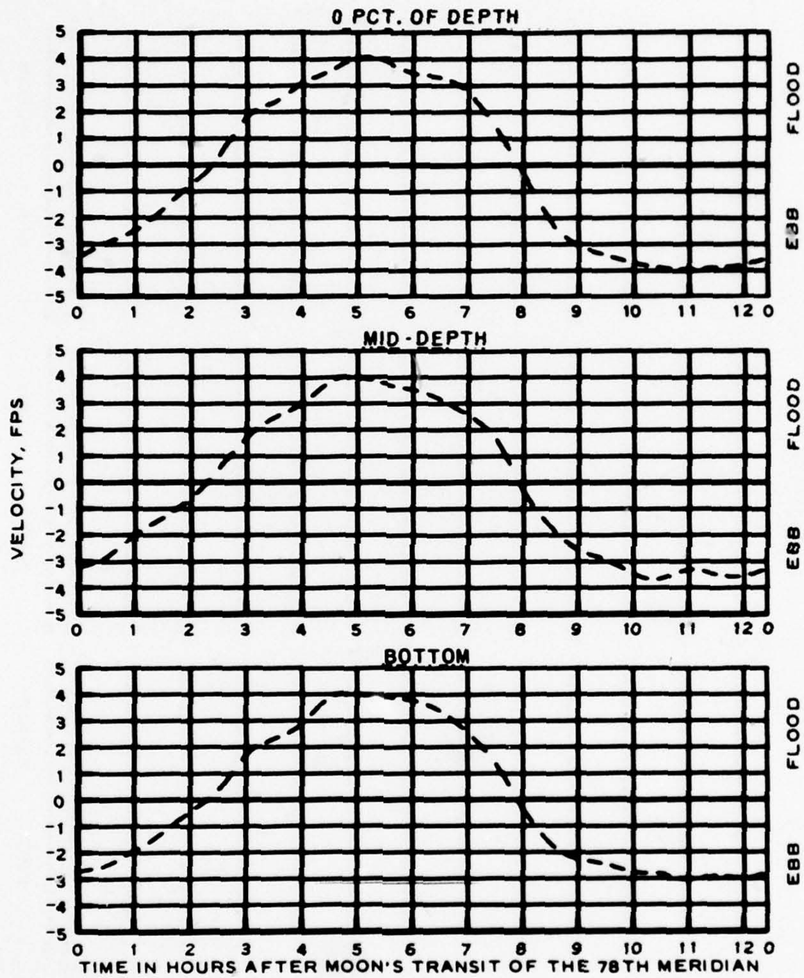
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES
STATION
16B




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

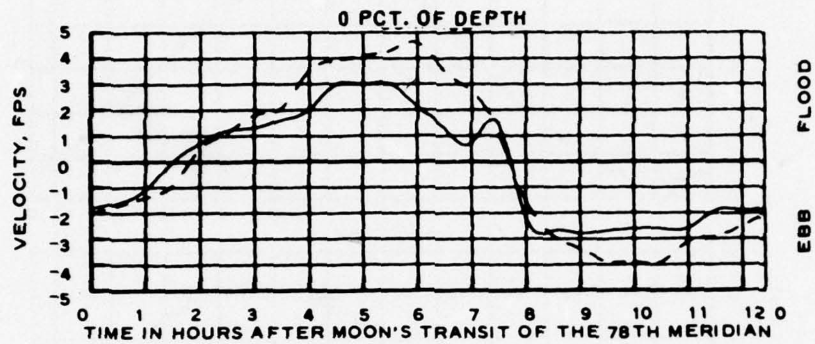
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D
ON VELOCITIES

STATION
16C




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

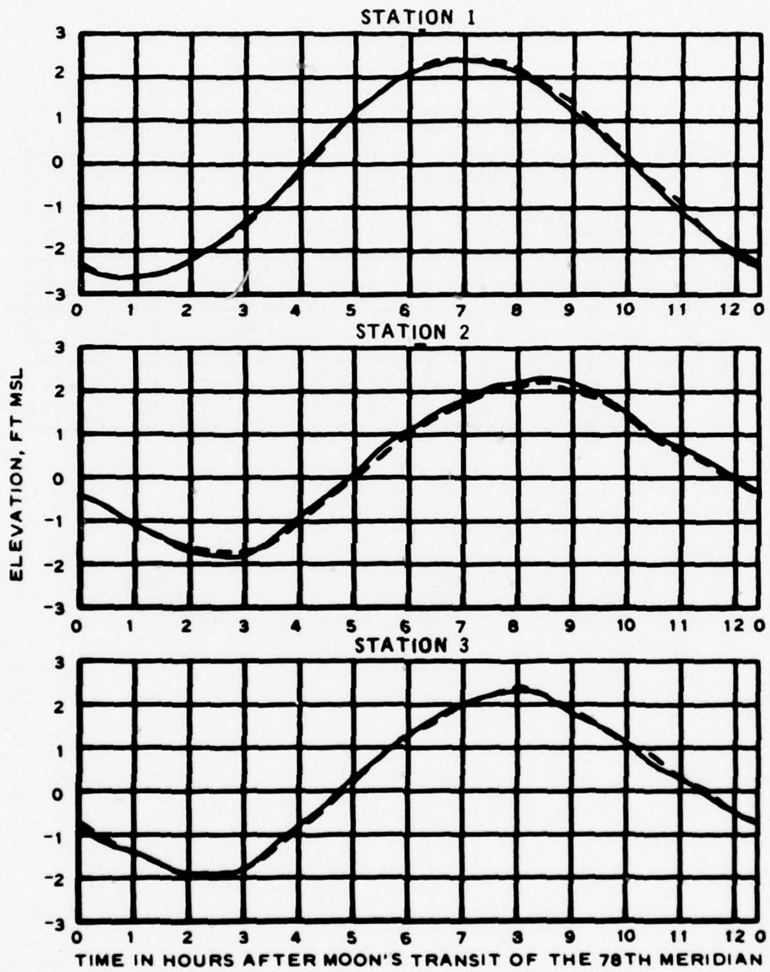
LEGEND

——— BASE

– – – – PLAN 2D

EFFECTS OF PLAN 2D ON VELOCITIES

STATION MAD




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

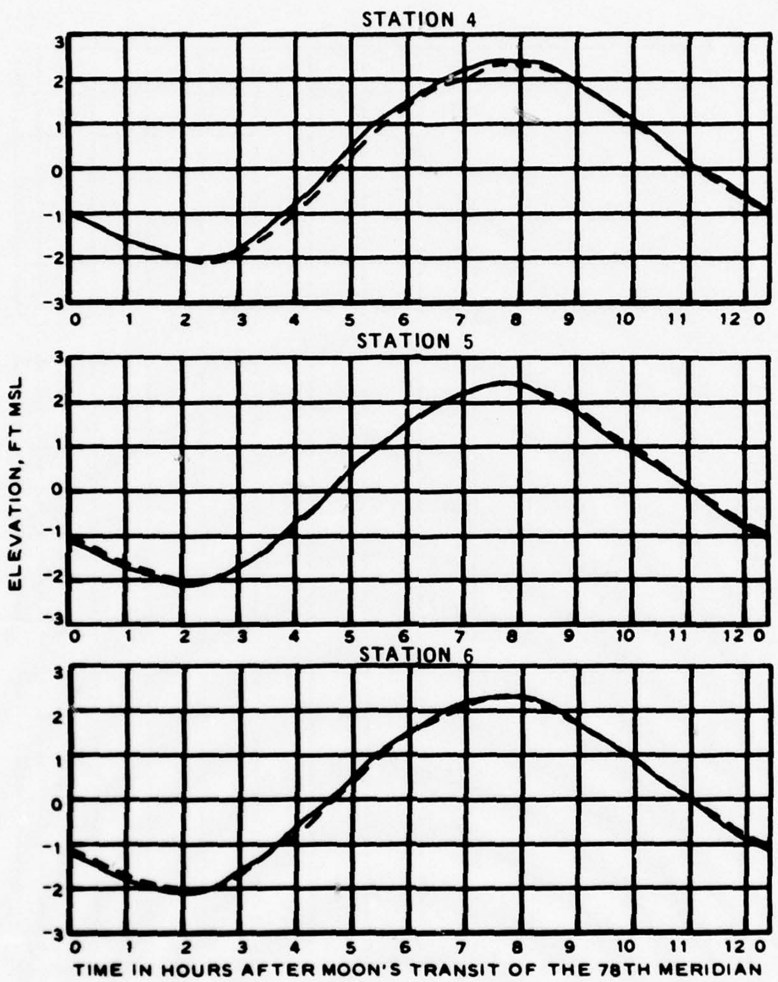
**LEGEND**

——— PLAN 2D

– – – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON TIDAL HEIGHTS

STATIONS 1, 2, AND 3




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

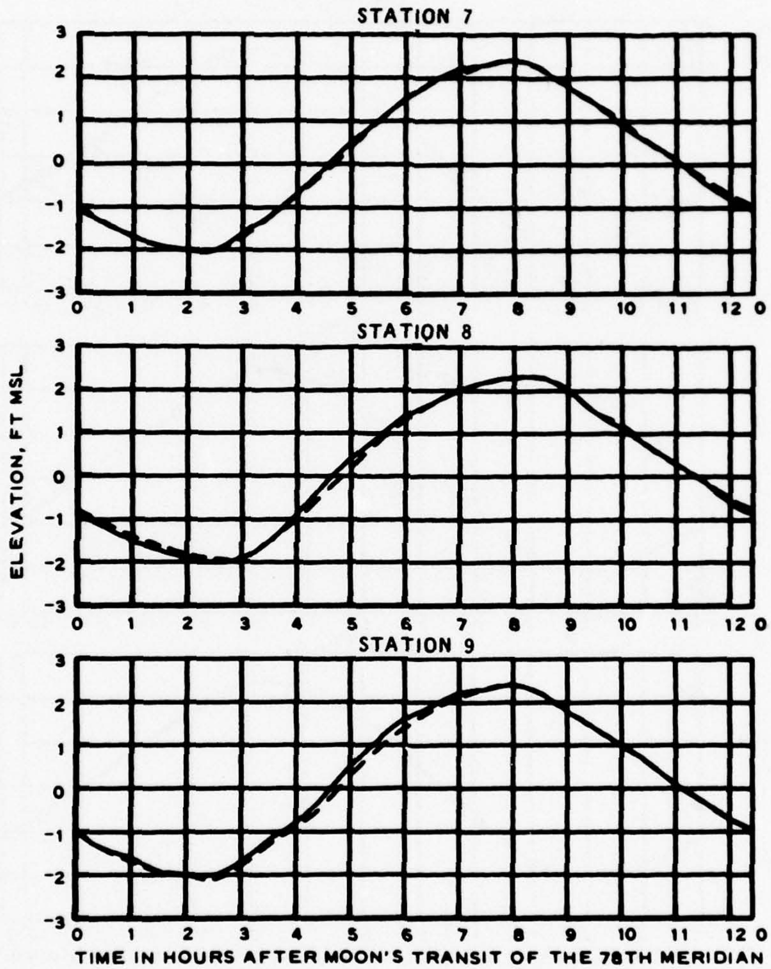
**LEGEND**

——— PLAN 2D

– – – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON TIDAL HEIGHTS

STATIONS 4, 5, AND 6




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

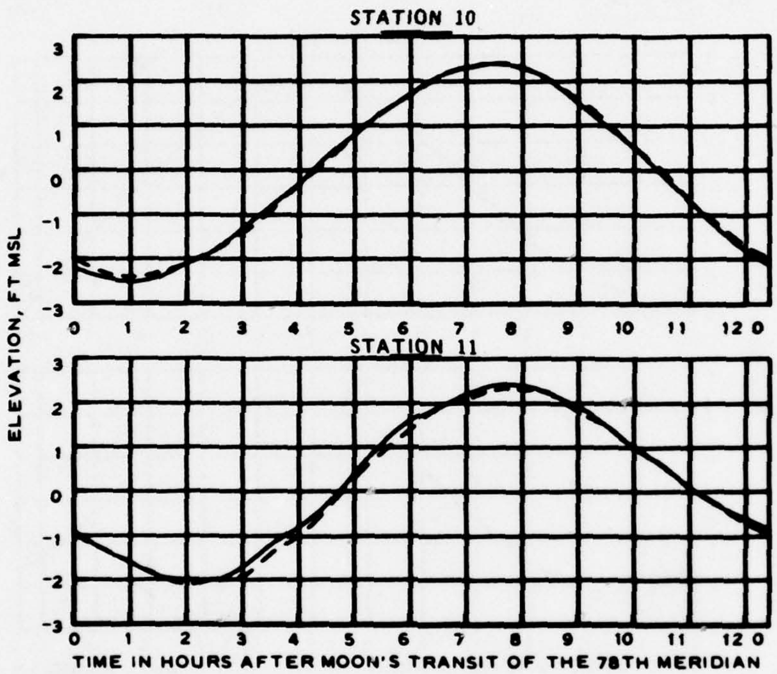
**LEGEND**

——— PLAN 2D

– – – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON TIDAL HEIGHTS

STATIONS 7, 8, AND 9




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

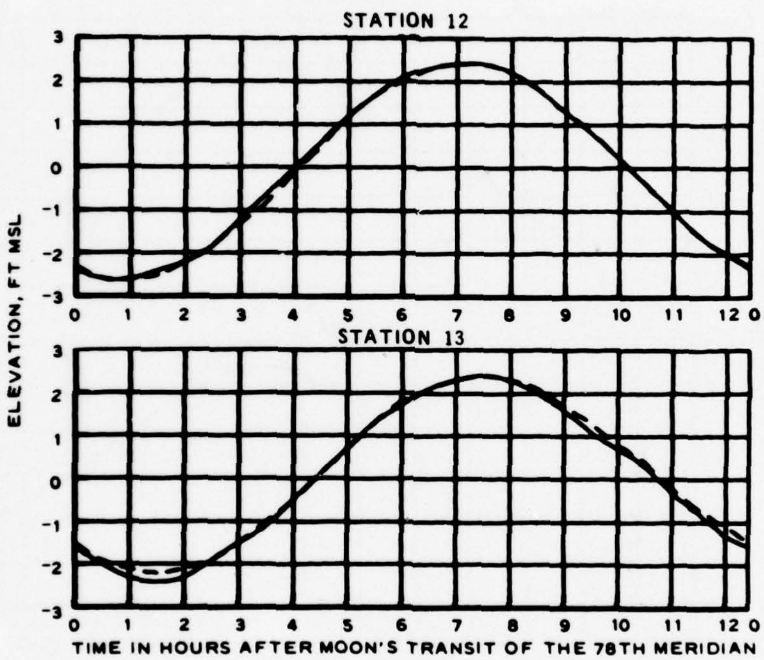
**LEGEND**

——— PLAN 2D

– – – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON TIDAL HEIGHTS

STATIONS 10 AND 11




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

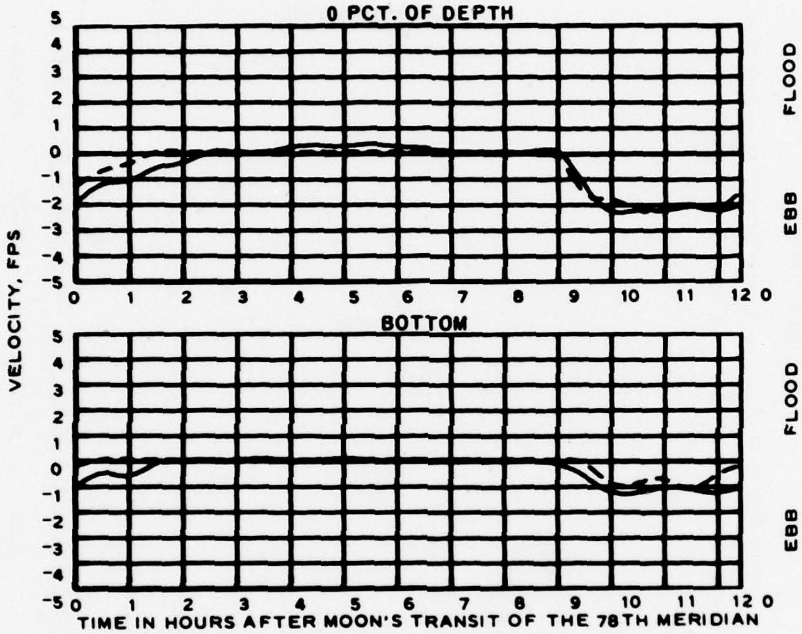
**LEGEND**

———— PLAN 2D

— — — — PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON TIDAL HEIGHTS

STATIONS 12 AND 13




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

LEGEND

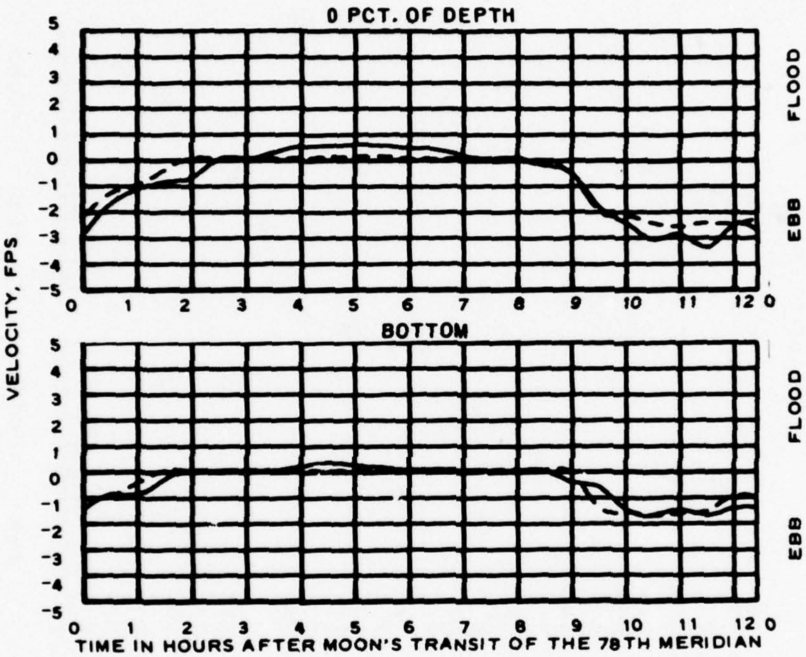
——— PLAN 2D

– – – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON VELOCITIES

STATIONS

8A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

LEGEND

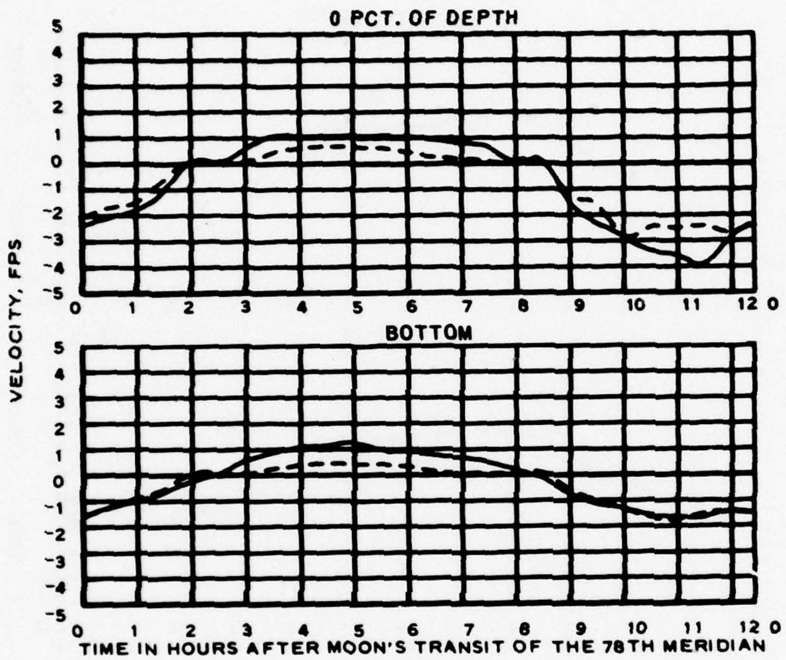
——— PLAN 2D

– – – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON VELOCITIES

STATIONS

9A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

LEGEND

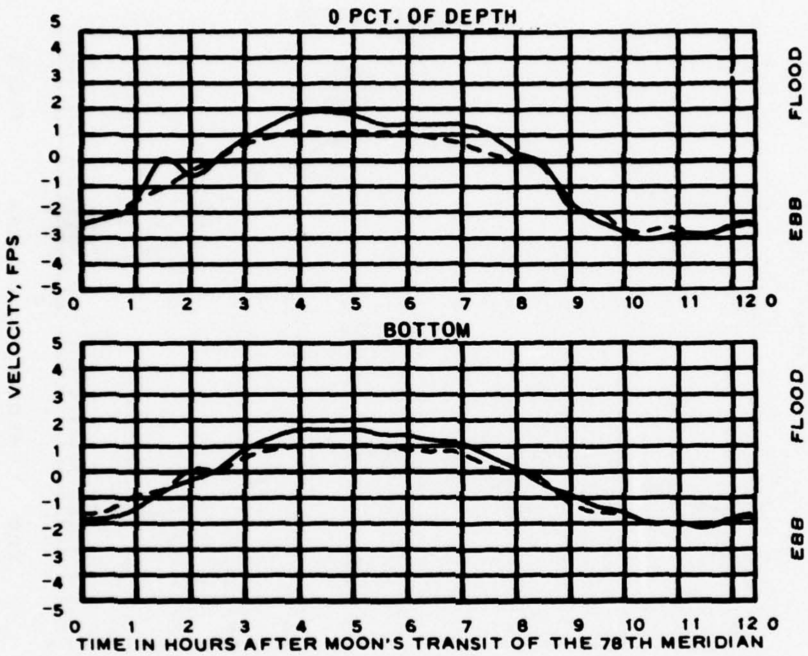
——— PLAN 2D

– – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON VELOCITIES

STATIONS

10A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

LEGEND

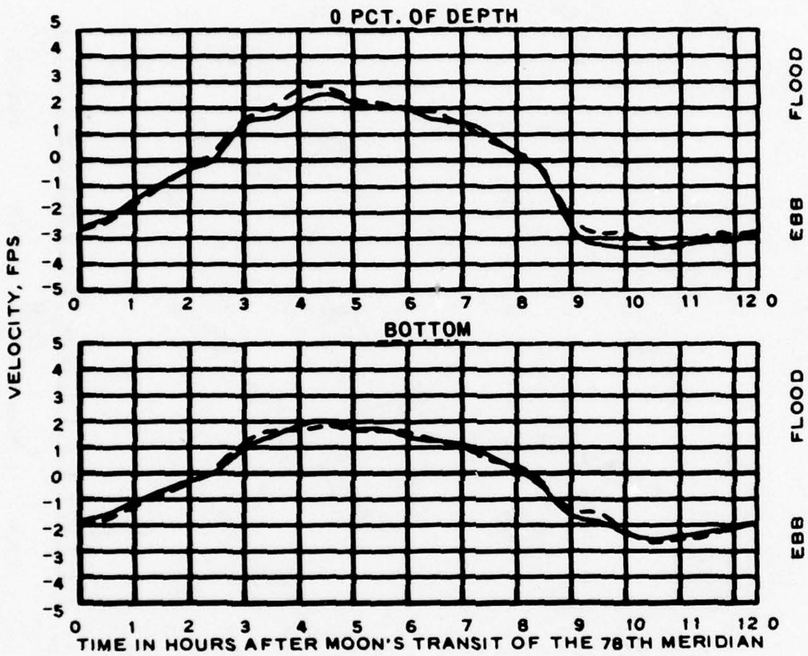
——— PLAN 2D

– – – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON VELOCITIES

STATIONS

11A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

LEGEND

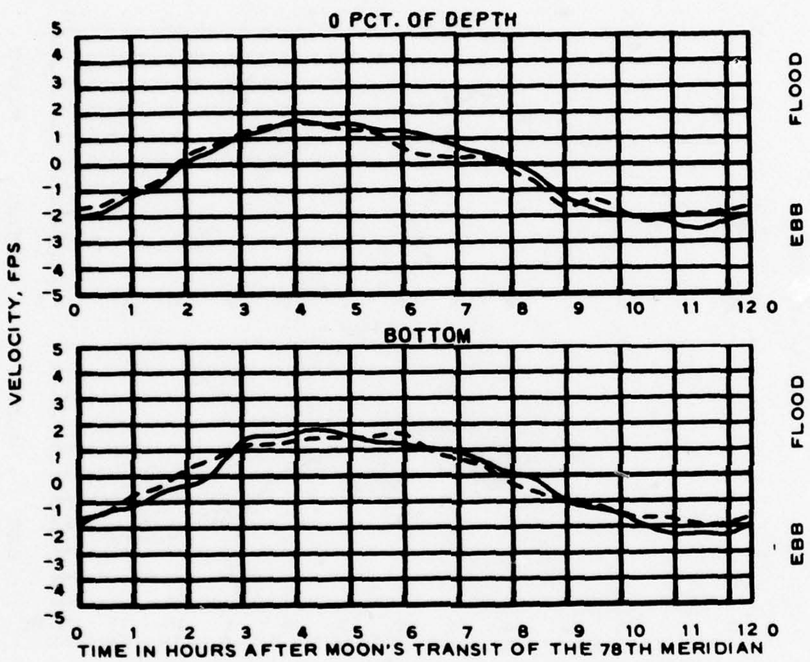
——— PLAN 2D

– – – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON VELOCITIES

STATIONS

12A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

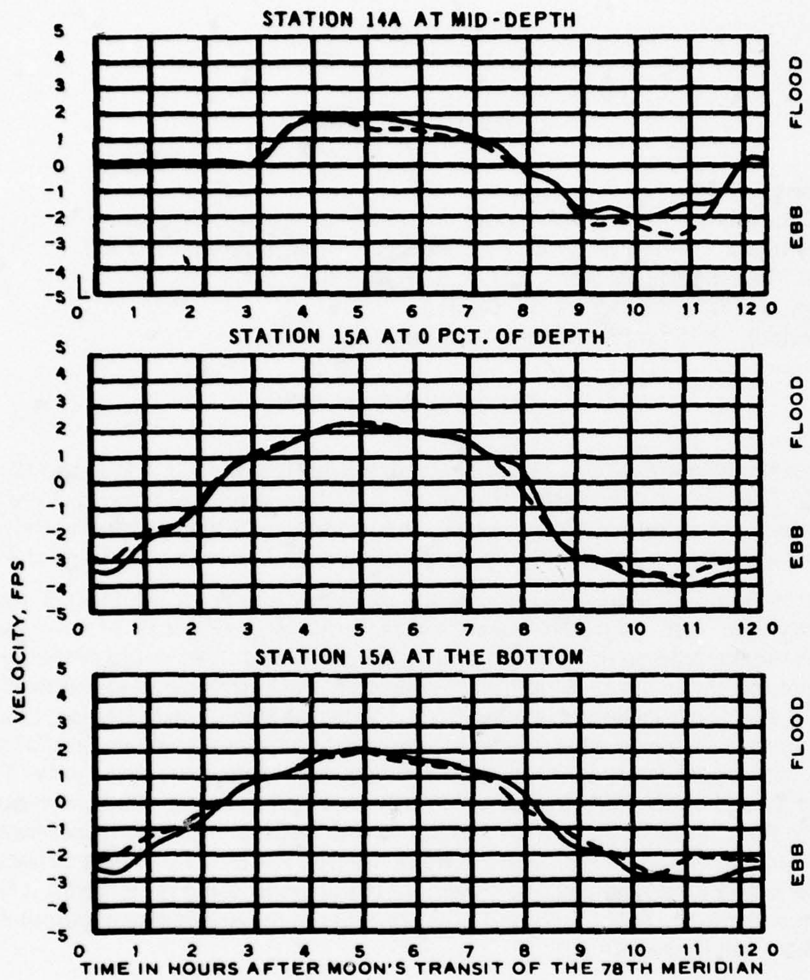
LEGEND

——— PLAN 2D

— — — PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON VELOCITIES

STATIONS
13A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

2D = PLAN 2D WITH JETTIES EXTENDED TO THE -12 FT CONTOUR

2D1 = PLAN 2D WITH JETTIES EXTENDED TO THE -8 FT CONTOUR

LEGEND

——— PLAN 2D

– – – – PLAN 2D1

EFFECTS OF REDUCING JETTY LENGTHS ON VELOCITIES

STATIONS 14A, 15A, AND 15A

## TEST CONDITIONS

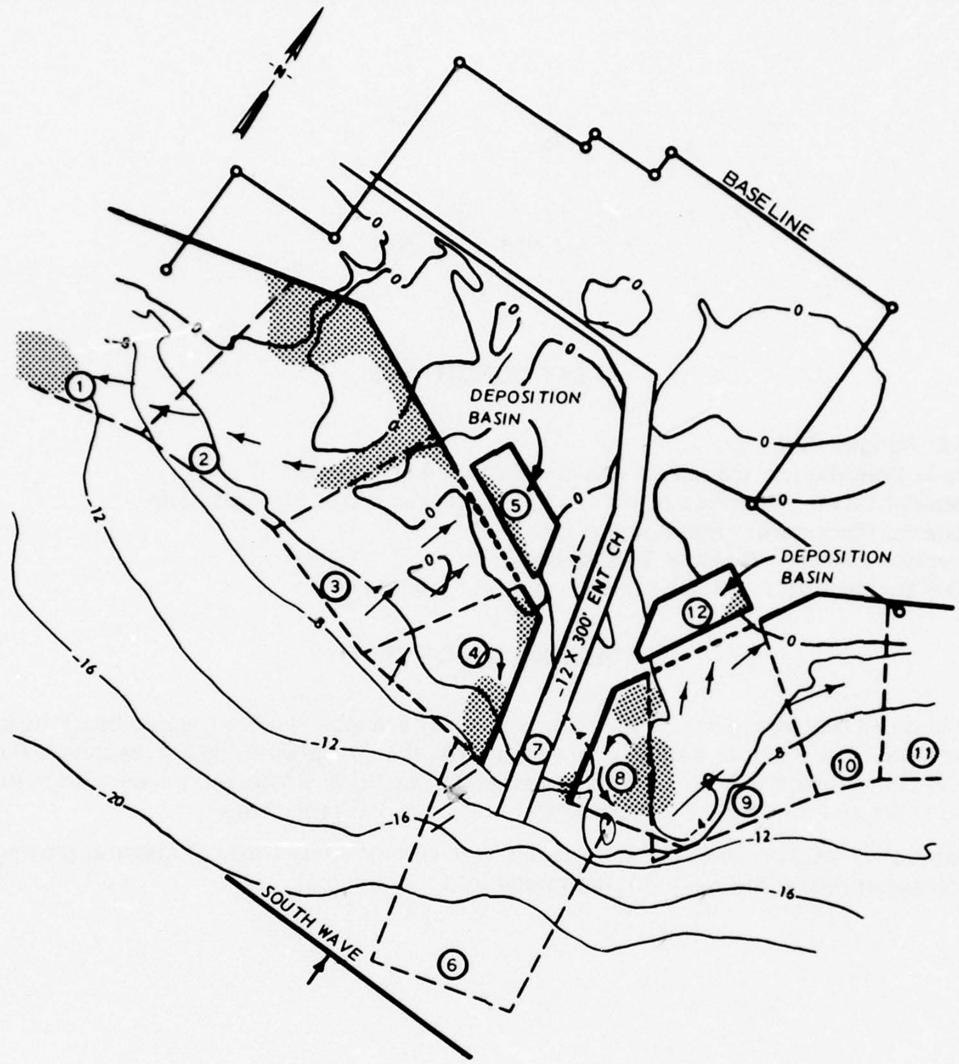
**Tide Range:** 5 ft
**Wave Conditions:** Direction—South, Height—4.6 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Regions 2, 3, 4, 8, 9, and 10
**Duration of Test:** 6 Model Tidal Cycles
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

A layer of plastic material was placed uniformly over Regions 2, 3, 4, 8, 9, and 10 shown in Plate 89. The shaded areas show the location of the material at the end of the test, and the arrows show paths along which the tracer material generally moved. The approaching wave front was nearly perpendicular to the oceanward legs of the jetties.

Material in Region 2 tended to accumulate in the remnant of a channel blocked by the west jetty and then migrated toward block 1. A circulation cell of wave-generated currents tended to keep this pattern during the entire test. This would probably occur in the prototype until a bar built up from the beach to the basin on the west side. Material in Region 3 and some in Region 4 moved into the basin, Region 5. In Region 4, during the portion of the tidal cycle when the water level was below the weir elevation of mean sea level, a wave-generated current flowed oceanward along the west jetty. Traces of material moved oceanward from the tip of the west jetty during ebb flow, though none moved to the channel. On the east side, there was material movement oceanward along the east jetty in Region 8. Once the material neared the jetty tip, it was deflected away from the jetty and moved east, as shown by the arrows. Some material from Regions 8 and 9 moved into the basin, Region 12. The remainder moved west or accumulated in the circulation cell in Region 8.

**SEDIMENT TRACER TEST**
**TEST 1**




LEGEND

1 BLOCK IDENTIFICATION NUMBER
PATH OF MATERIAL MOVEMENT
MATERIAL LOCATION AT END OF TEST
TRACES OF MATERIAL

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

SEDIMENT TRACER STUDY
TEST 1

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—South, Height—4.6 ft, Period—7 sec
**Material Used:** Microbeads, S.G. = 2.42, Diameter = 0.062 to 0.088 mm
**Material Placement:** Regions 4 and 8
**Duration of Test:** 6 Model Tidal Cycles
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

This was a trial test to see if microbeads, a newly available material, would be useful in the study. The material, being somewhat heavier than the plastic, did not respond to the tide- and wave-generated currents as well as the plastic, but observations were made for the short and long jetty conditions (test 2 and test 3, respectively).

Generally, results were similar to test 1 with a very small trace of material moving oceanward along the west jetty and none into the channel.

**SEDIMENT TRACER TEST**
**TEST 2**

## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—South, Height—4.6 ft, Period—7 sec
**Material Used:** Microbeads, S.G. = 2.42, Diameter = 0.062 to 0.088 mm
**Material Placement:** Regions 4 and 8
**Duration of Test:** 6 Model Tidal Cycles
**Plan Tested:** 2D (Jetties extend to the -12 ft contour)

## DISCUSSION OF TEST

The results were very similar to the preceding test with limited movement occurring past the west jetty tip and none past the east jetty tip. Thus, no difference in material movement between the short and long jetty configurations was noted when using microbeads as a tracer.

**SEDIMENT TRACER TEST**
**TEST 3**

## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—South, Height—4.6 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Regions 2, 3, 4, 8, 9, and 10
***Duration of Test:*** *8 Model Tidal Cycles*
**Plan Tested:** 2D (Jetties extend to the -12 ft contour)

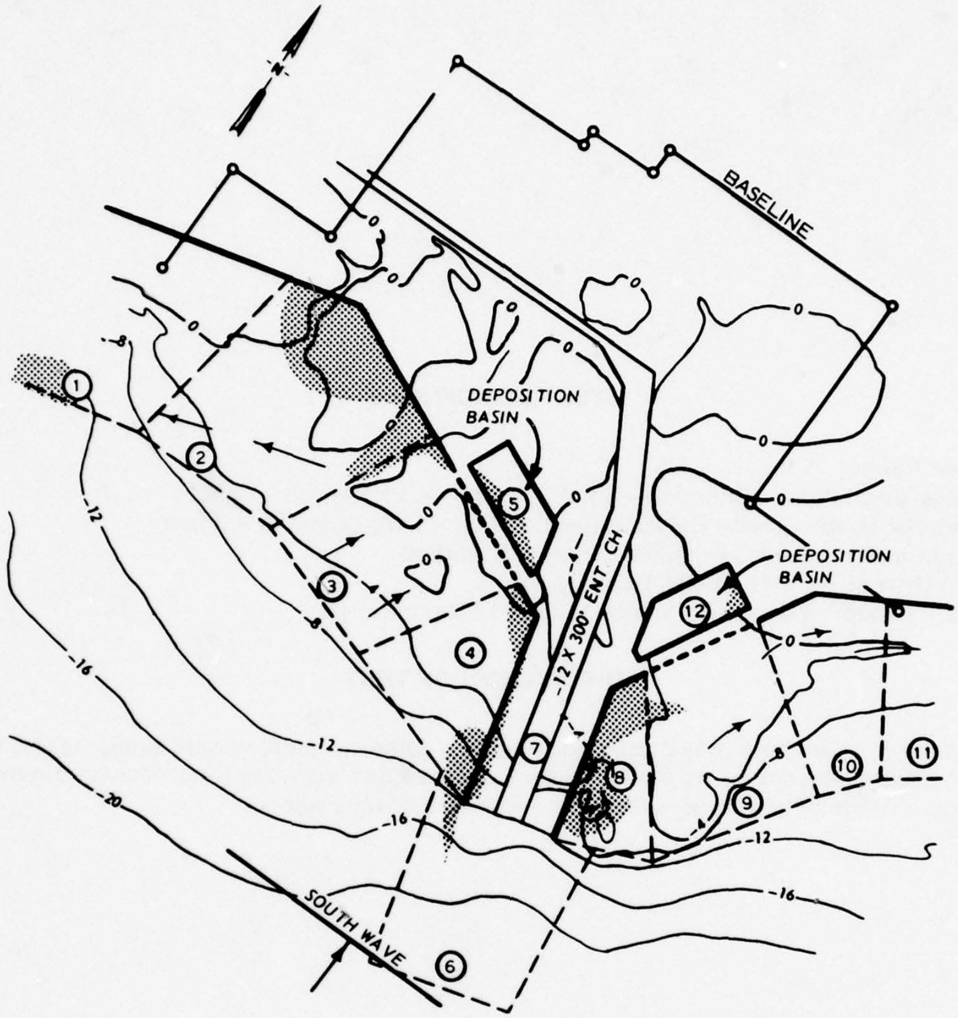
## DISCUSSION OF TEST

Movement patterns were similar to test 1. The only difference in test 4 and test 1 was the length of the jetties. The longer jetties of this test did not change any of the sediment patterns noted at the end of test 1. Therefore, for a wave approaching nearly perpendicular to the jetty legs, there was no significant difference of material movement patterns for the jetties extending to the -12 ft contour or to the -8 ft contour.

The west basin filled heavily, and there was some filling of the east basin, with some material moving in an eastward direction as shown in Plate 93.

An interesting effect of wave diffraction was noted at the junction of the west weir section and the beginning of the rubble-mound portion of the west jetty. Some material that was transported over the weir was transported by diffracted waves toward the interior portion of the navigation channel. The amount of material was only in traces, however.

**SEDIMENT TRACER TEST**
**TEST 4**




LEGEND

① BLOCK IDENTIFICATION NUMBER
PATH OF MATERIAL MOVEMENT
MATERIAL LOCATION AT END OF TEST
NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

SEDIMENT TRACER STUDY
TEST 4

SCALES IN FEET

PROTOTYPE 600 0 600 1200
MODEL 2 0 2 4

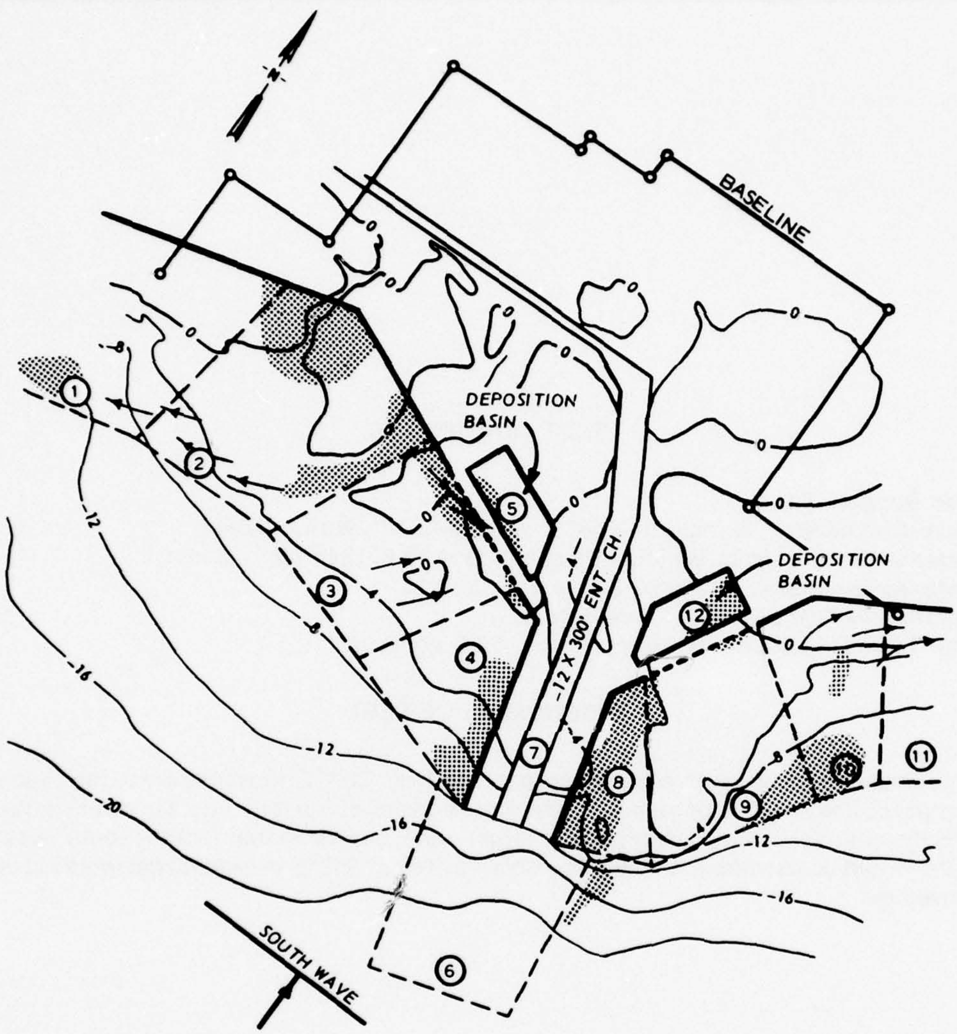
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—South, Height—2.3 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Regions 2, 3, 4, 8, 9, and 10
**Duration of Test:** 6 Model Tidal Cycles
**Plan Tested:** 2D (Jetties extend to the -12 ft contour)

## DISCUSSION OF TEST

A smaller wave height was examined in this test. Other conditions were similar to test 4. Movement patterns were similar to tests 1 and 4, except there was little movement in the region of the jetty tips. Movement into the basins was evident.

**SEDIMENT TRACER TEST**
**TEST 5**




LEGEND

1 BLOCK IDENTIFICATION NUMBER
PATH OF MATERIAL MOVEMENT
MATERIAL LOCATION AT END OF TEST
NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

**SEDIMENT TRACER STUDY**
**TEST 5**

SCALES IN FEET

PROTOTYPE 600 0 600 1200
MODEL 2 0 2 4

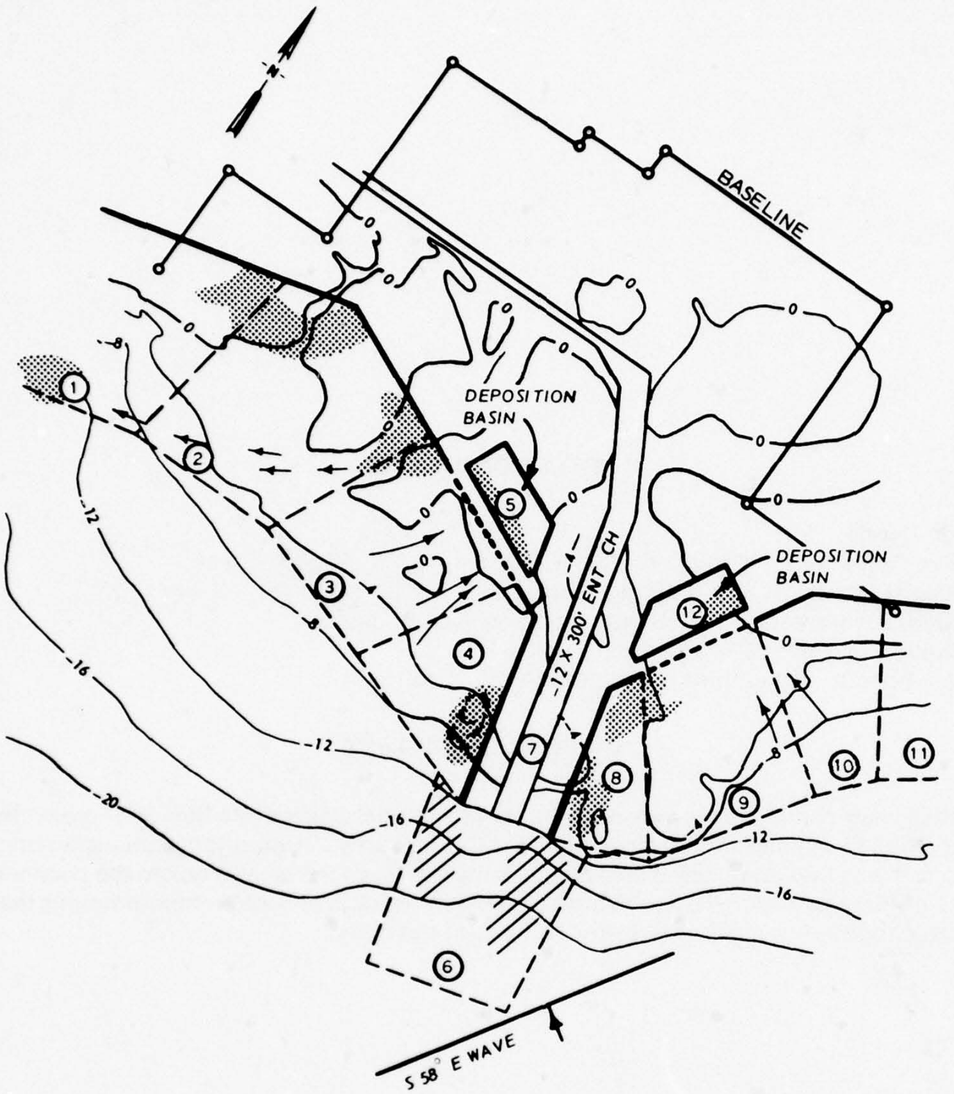
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S58° E, Height—2.7 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Regions 2, 3, 4, 8, 9, and 10
**Duration of Test:** 6 Model Tidal Cycles
**Plan Tested:** 2D (Jetties extend to the -12 ft contour)

## DISCUSSION OF TEST

This was the first test with a wave approaching from S58° E. Movement into the basins occurred. Some traces of material moved oceanward of the jetty tips, but none moved into the channel. It was decided that a larger wave, similar to that for the "south" wave tests, would be used for the next test with a wave from S58° E in order to get more active movement.

**SEDIMENT TRACER TEST**
**TEST 6**




LEGEND

① BLOCK IDENTIFICATION NUMBER

PATH OF MATERIAL MOVEMENT

MATERIAL LOCATION AT END OF TEST

TRACES OF MATERIAL

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

SEDIMENT TRACER STUDY
TEST 6

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

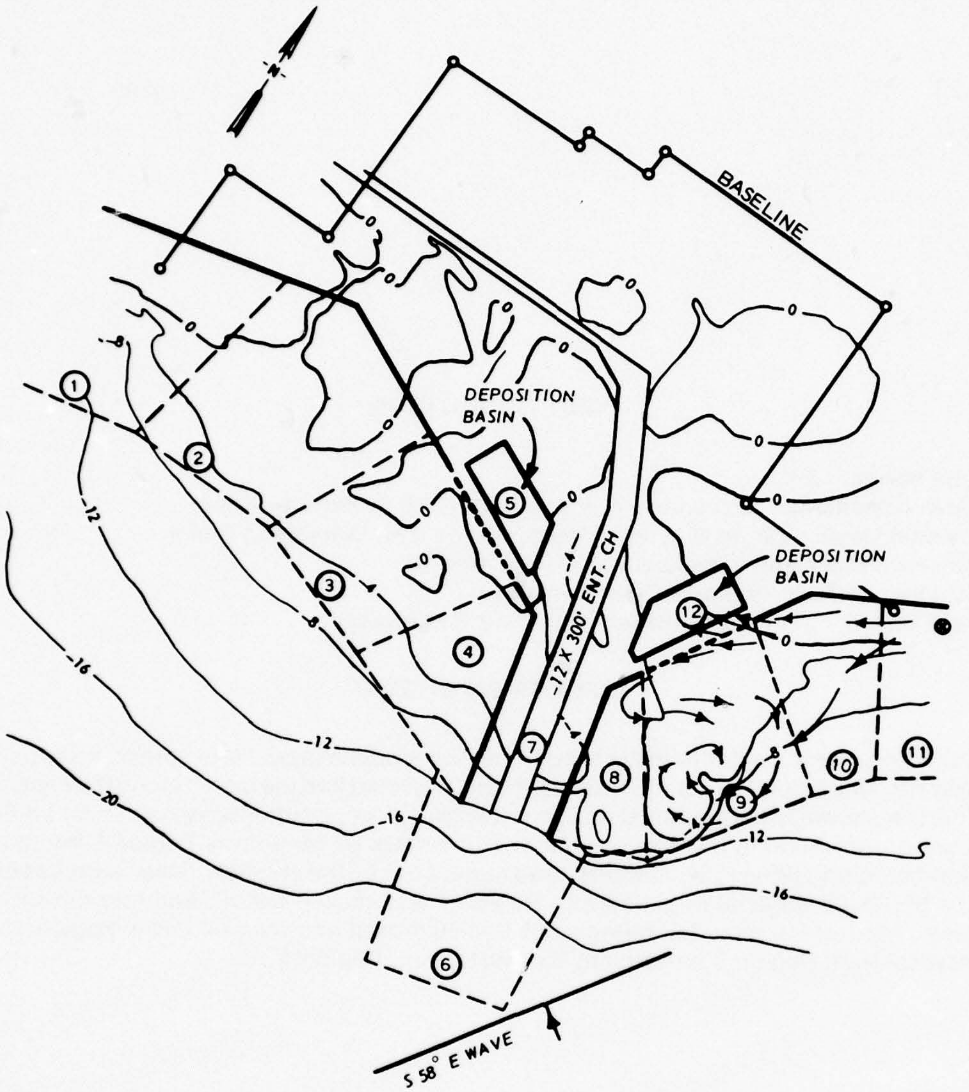
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S58° E, Height—4.6 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Injection at Location East of Jetties
**Duration of Test:** 2 Model Tidal Cycles
**Plan Tested:** 2D (Jetties extend to the -12 ft contour)

## DISCUSSION OF TEST

With a wave coming in at an angle to the shore, material was fed into Region 11 along the shoreline to simulate littoral movement into the inlet area. An important conclusion from the test was that no material migrated around the tip of the east jetty into the channel. The primary path of travel was to the east deposition basin except for small amounts that were caught in circulation patterns in front of the basin.

**LITTORAL DRIFT INJECTION TEST**
**TEST 7**




LEGEND

① BLOCK IDENTIFICATION NUMBER
PATH OF MATERIAL MOVEMENT
POINT OF MATERIAL INSERTION
NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

LITTORAL DRIFT
INJECTION STUDY
TEST 7

SCALES IN FEET

PROTOTYPE 600 0 600 1200
MODEL 2 0 2 4

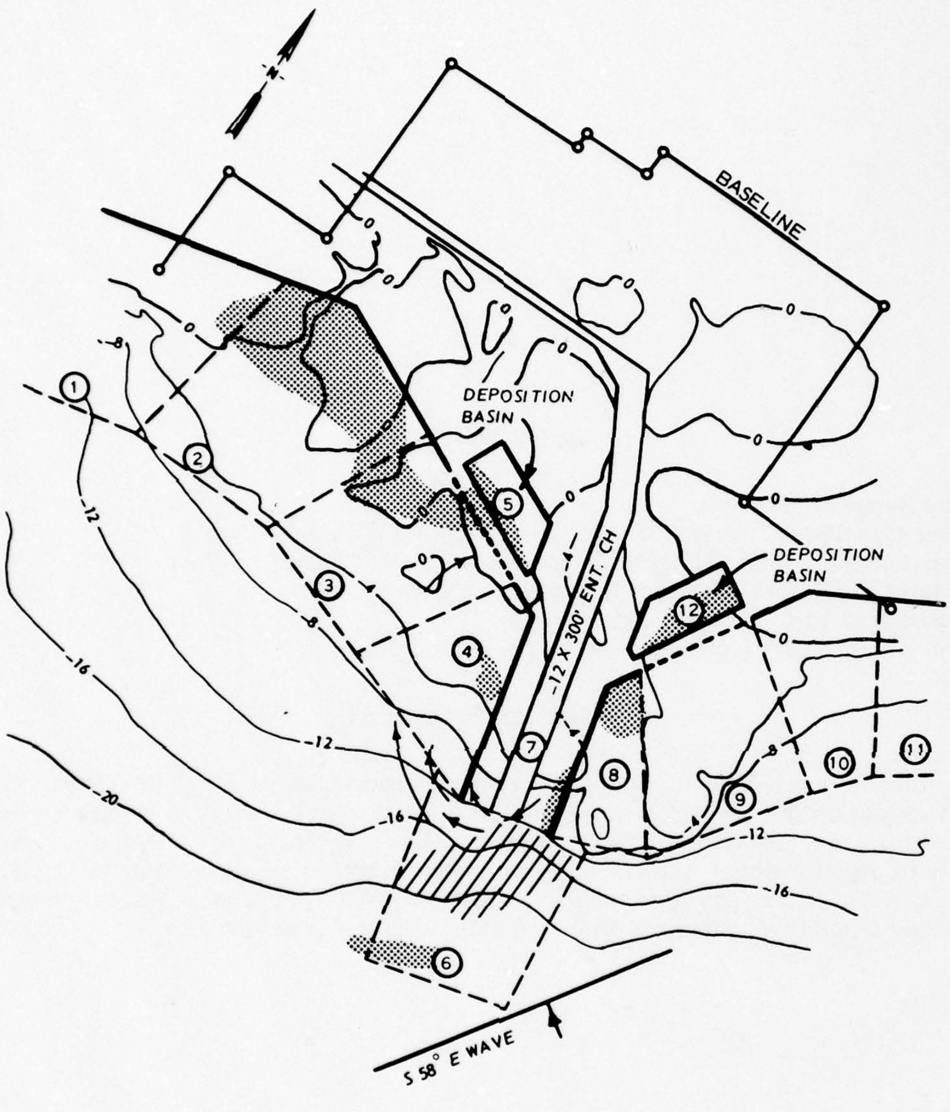
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S58° E, Height—4.6 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Regions 2, 3, 4, 8, 9, and 10
**Duration of Test:** 6 Model Tidal Cycles
**Plan Tested:** 2D (Jetties extend to the -12 ft contour)

## DISCUSSION OF TEST

Conditions were similar to test 7 except that the model material was spread uniformly over Regions 2, 3, 4, 8, 9, and 10 instead of being injected into the model along the beach. This test showed where material movement would occur just after construction for a 4.6-ft wave, representing a storm condition. Some material came from Region 8 into the channel during flood flow; however, it was swept out by the ebb flow. Small amounts of this bypassed material migrated into Region 4 and moved toward and into the west basin. Most of the material in Regions 9 and 10 moved into the east basin, Region 12. Material from Region 3 moved into the west basin, Region 5.

**SEDIMENT TRACER TEST**
**TEST 8**




LEGEND

| | |
|---|---|
| (1) | BLOCK IDENTIFICATION NUMBER |
| | PATH OF MATERIAL MOVEMENT |
| | MATERIAL LOCATION AT END OF TEST |
| | TRACES OF MATERIAL |

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

SEDIMENT TRACER STUDY
TEST 8

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

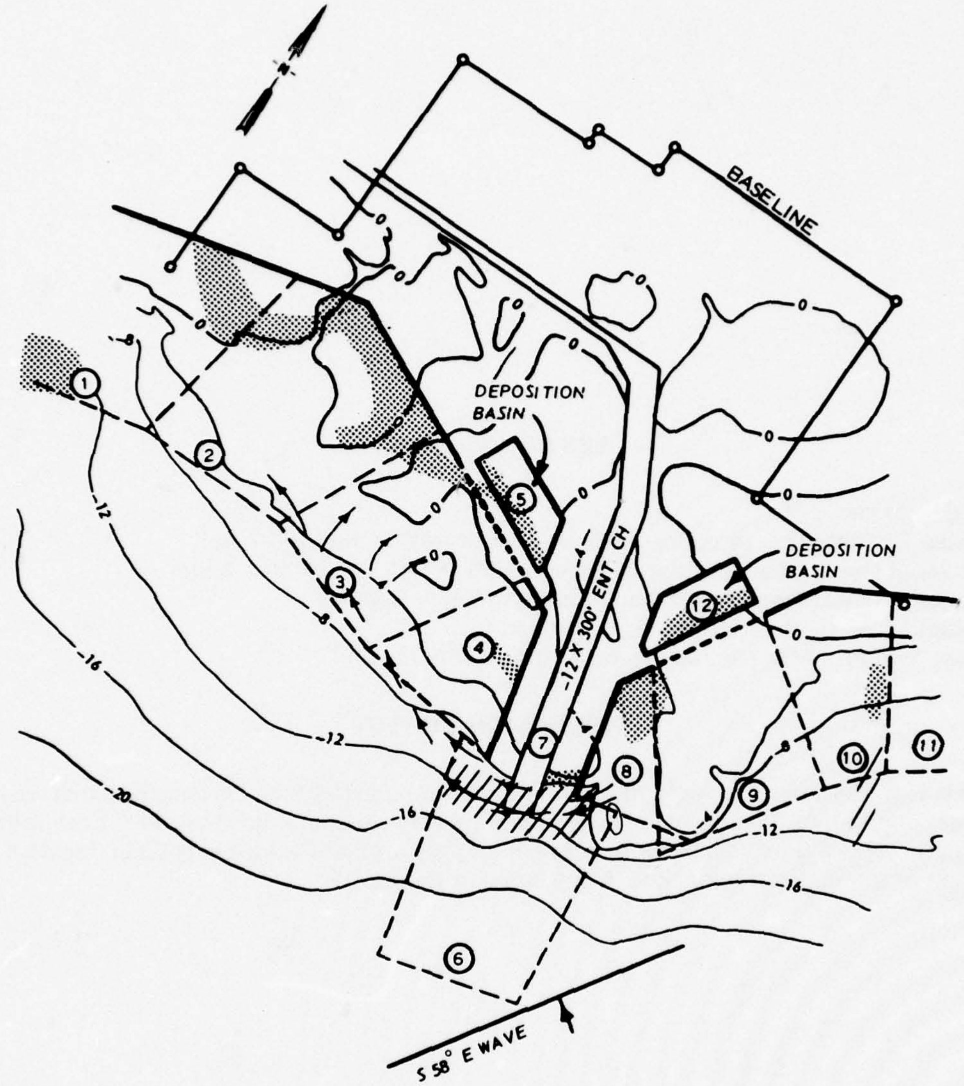
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S58° E, Height—4.6 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Regions 2, 3, 4, 8, 9, and 10
**Duration of Test:** 6 Model Tidal Cycles
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

Conditions were similar to test 8 except that the shorter jetties were installed. Therefore, the results of this test can be compared with test 8 to note the effect of jetty length. Movement was identical with that discussed for test 8. At the end of the test, there were only traces of material in the channel and between the jetties. Therefore, the shorter jetties did not cause any substantial changes from test 8. For the above test conditions, the two different jetty lengths produced essentially the same results.

**SEDIMENT TRACER TEST**
**TEST 9**




LEGEND

(1) BLOCK IDENTIFICATION NUMBER
PATH OF MATERIAL MOVEMENT
MATERIAL LOCATION AT END OF TEST
TRACES OF MATERIAL

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

**SEDIMENT TRACER STUDY**
**TEST 9**

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

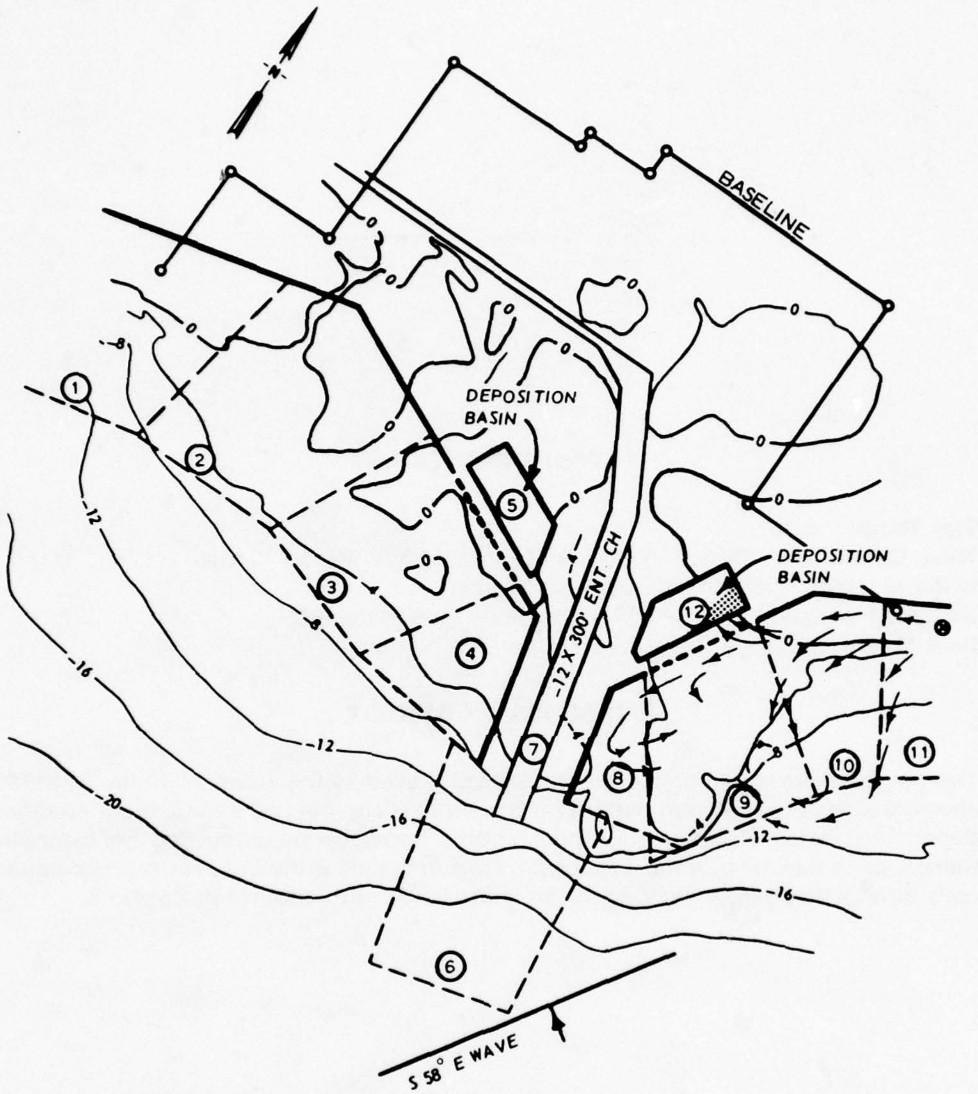
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S58° E, Height—4.6 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Injection at Location East of Jetties
**Duration of Test:** 2 Model Tidal Cycles
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

This test was similar to test 7 except that the jetties were reduced in length so that they extended to the -8 ft contour. The results were very similar to those of test 7. Even with shorter jetties, the littoral material did not migrate around the east jetty tip in Region 8. Most of the material deposited in the basin in Region 12.

**LITTORAL DRIFT INJECTION TEST**
**TEST 10**




LEGEND

- BLOCK IDENTIFICATION NUMBER
- PATH OF MATERIAL MOVEMENT
- MATERIAL LOCATION AT END OF TEST
- POINT OF MATERIAL INSERTION

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

LITTORAL DRIFT INJECTION STUDY
TEST 10

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

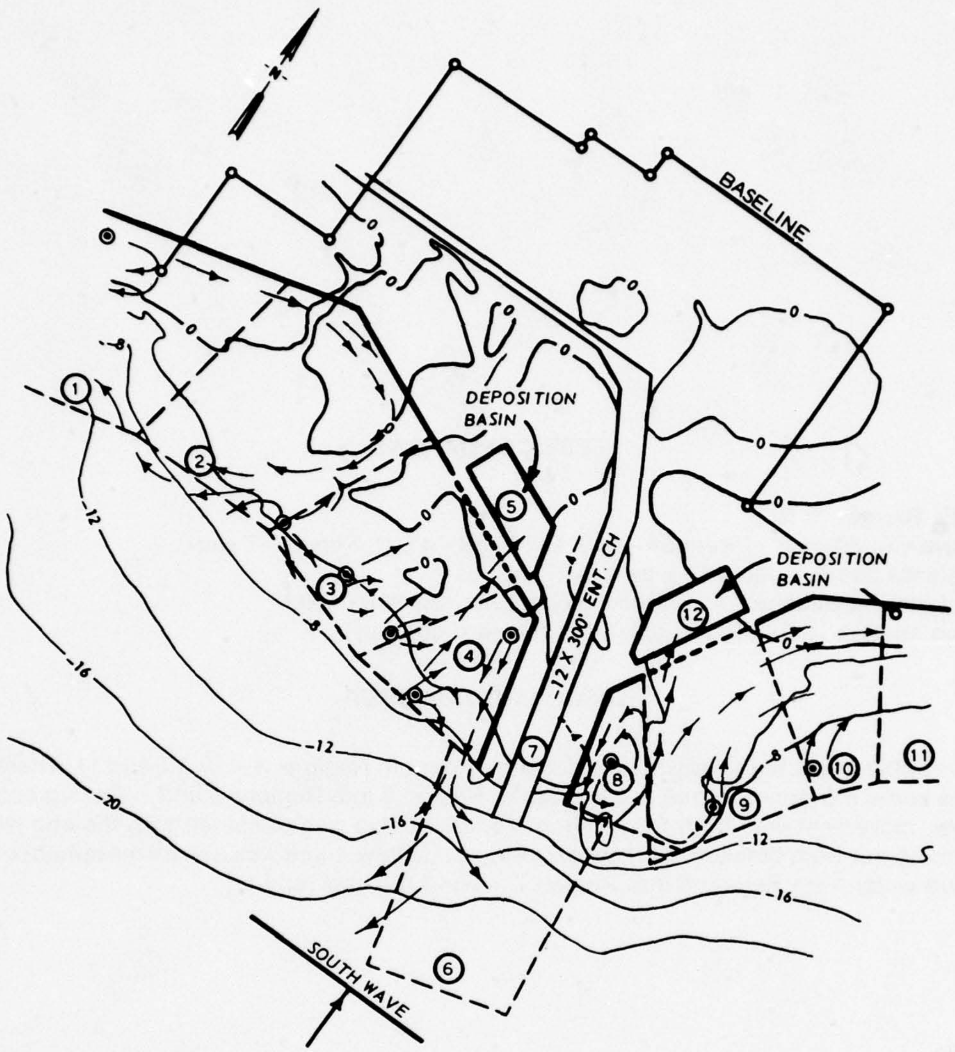
**TEST CONDITIONS**

**Tide Range:** 5 ft
**Wave Conditions:** Direction—South, Height—4.6 ft, Period—7 sec
**Material Used:** Liquid Dye and Dye Crystals
**Material Placement:** At Selected Locations (see Plate 106)
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

**DISCUSSION OF TEST**

The purpose was to examine current patterns caused by the waves and tide. Plate 106 shows the usual circulation pattern for the south wave, but there were minor changes depending on tidal elevation and whether ebb or flood flow was occurring. For example, there was no flow toward the west basin, Region 5, during the ebb. Various circulation cells developed such as the one in Regions 1 and 2 and another in Region 8.

**DYE MOVEMENT TEST**
**TEST 11**




LEGEND

(1) BLOCK IDENTIFICATION NUMBER

PATHS OF DYE MOVEMENTS

POINT OF DYE INSERTION

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

DYE MOVEMENT STUDY
TEST 11

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

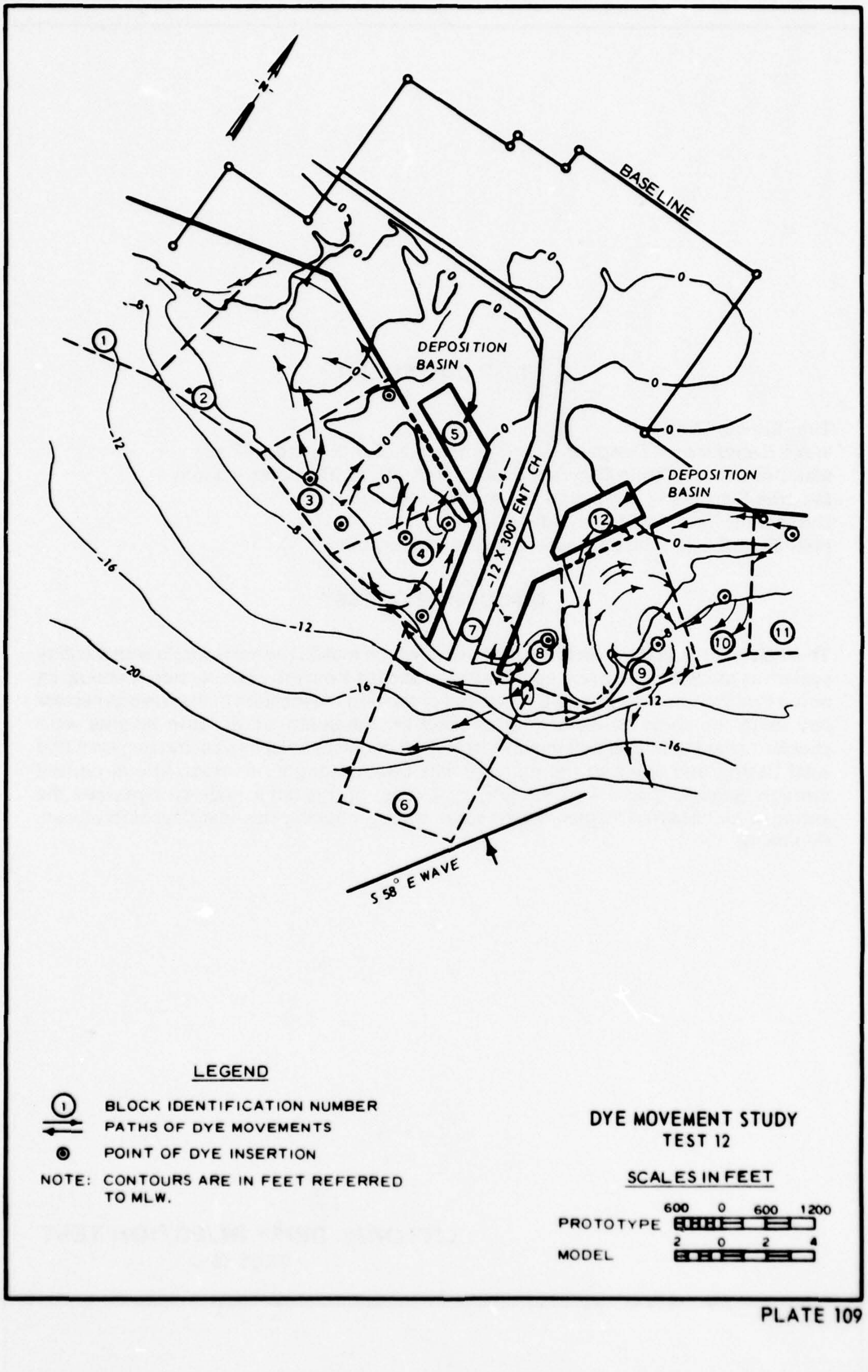
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S58° E, Height—4.6 ft, Period—7 sec
**Material Used:** Liquid Dye and Dye Crystals
**Material Placement:** At Selected Locations (see Plate 109)
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

Currents toward the deposition basins are evident in Regions 3, 4, 9, 10, and 11. There was some movement of the water mass in Region 8 into Regions 6 and 7. During ebb flow, movement was from Region 8 into 6, as the dye was entrained with the ebb jet coming out from between the jetties. During flood flow, there was a small movement of dyed water from Region 8 into Region 7 around the east jetty tip.

**DYE MOVEMENT TEST**
**TEST 12**


BASELINE
DEPOSITION BASIN
DEPOSITION BASIN
-12 X 300' ENT CH
S 58° E WAVE
LEGEND
BLOCK IDENTIFICATION NUMBER
PATHS OF DYE MOVEMENTS
POINT OF DYE INSERTION
NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.
DYE MOVEMENT STUDY
TEST 12
SCALES IN FEET
600 0 600 1200
PROTOTYPE
2 0 2 4
MODEL

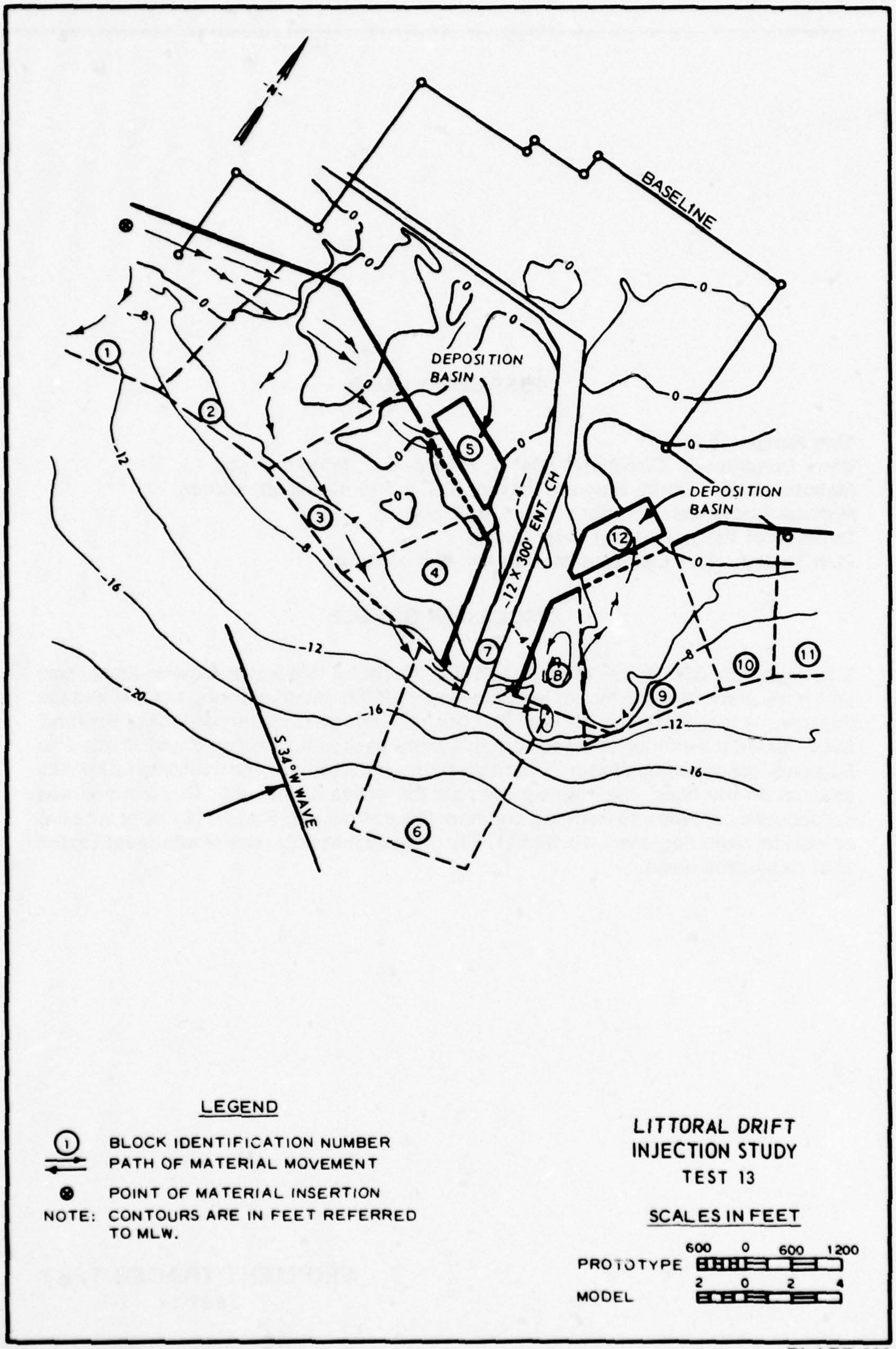
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S34° W, Height—7.5 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Injection at Location West of Jetties
**Duration of Test:** 2 Model Tidal Cycles
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

This test was the first to use the S34° W wave which makes the same angle with the jetty system as the S58° E wave except that it approaches from the westerly side. It should be noted that the wave height is 7.5 ft, a result of moving the location of the wave generator but using the same stroke setting as used for the south wave. Wave heights were checked after the littoral drift injection test. Part of the material moved into Region 5 (the west basin), and some of the material was swept along by a strong littoral current through Regions 3 and 4 to the jetty tips. Most of this latter material bypassed the entrance and entered Region 8 with some traces reaching the east deposition basin, Region 12.

**LITTORAL DRIFT INJECTION TEST**
**TEST 13**



N
BASELINE
DEPOSITION BASIN
DEPOSITION BASIN
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S 34° W WAVE
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-12
-16
-20
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3
4
5
6
7
8
9
10
11
12
LEGEND
BLOCK IDENTIFICATION NUMBER
PATH OF MATERIAL MOVEMENT
POINT OF MATERIAL INSERTION
NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.
LITTORAL DRIFT
INJECTION STUDY
TEST 13
SCALES IN FEET
PROTOTYPE
600 0 600 1200
MODEL
2 0 2 4


PLATE 111

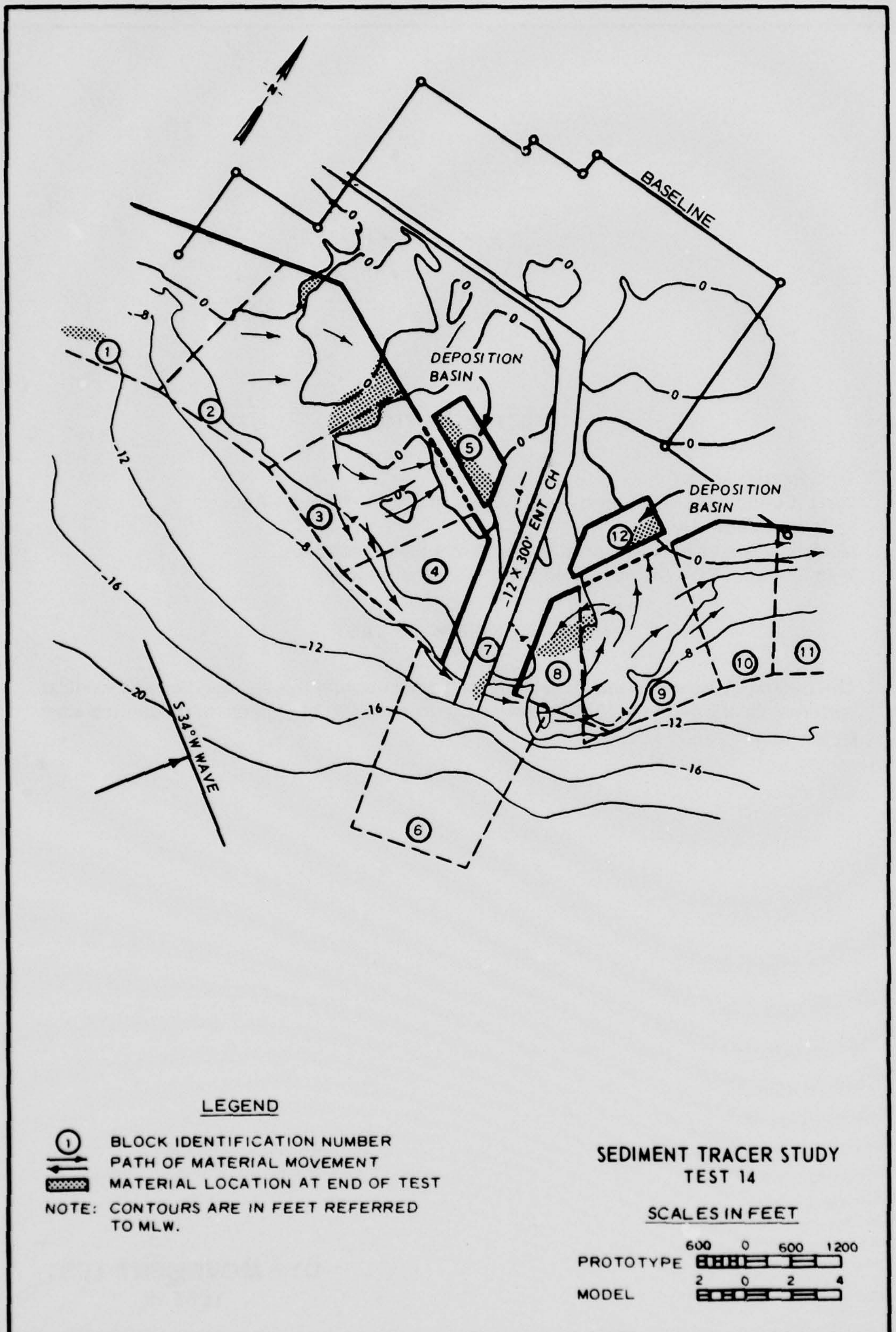
### TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S34° W, Height—5 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Regions 2, 3, 4, 8, 9, and 10
**Duration of Test:** 6 Model Tidal Cycles
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

### DISCUSSION OF TEST

The wave from S34° W was reduced to 5 ft in height for this test and the sediment was uniformly placed on the model bed. Movement of the material during the test and the final results (see Plate 113) showed that once the deeper channel portions of Region 2 filled, material was then allowed to move more easily into Region 3 and finally into Region 5, the deposition basin. Some material migrated around the west jetty tip into the channel on the flood, then moved out past the jetties on the ebb. This material was subsequently moved into Region 8 and from there either into Region 12 (the east basin) or west through Regions 9, 10, and 11. The greatest mass of material was caught in the west deposition basin.

**SEDIMENT TRACER TEST**
**TEST 14**



BASELINE
DEPOSITION BASIN
DEPOSITION BASIN
-12 X 300' ENT CH
S 34°W WAVE
1
2
3
4
5
6
7
8
9
10
11
12
0
-8
-12
-16
-20
LEGEND
BLOCK IDENTIFICATION NUMBER
PATH OF MATERIAL MOVEMENT
MATERIAL LOCATION AT END OF TEST
NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.
SEDIMENT TRACER STUDY
TEST 14
SCALES IN FEET
600 0 600 1200
PROTOTYPE
2 0 2 4
MODEL

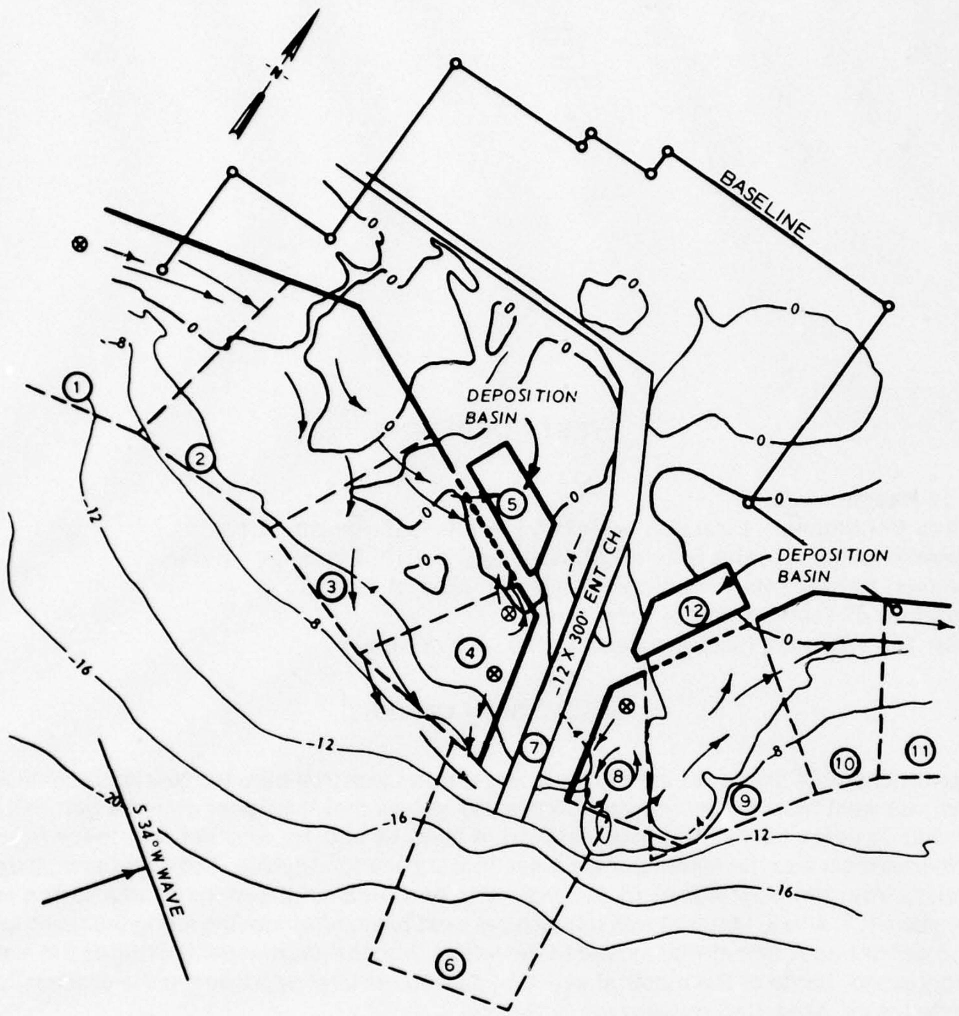
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S34°W, Height—5 ft, Period—7 sec
**Material Used:** Dye
**Material Placement:** At Selected Locations (see Plate 115)
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

The tracing of the wave- and tide-generated currents with dye showed generally similar patterns to those seen for the sediment tracer test 14, which had identical test conditions.

**DYE MOVEMENT TEST**
**TEST 15**




LEGEND

① BLOCK IDENTIFICATION NUMBER

PATHS OF DYE MOVEMENTS

⊗ POINT OF DYE INSERTION

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

DYE MOVEMENT STUDY
TEST 15

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

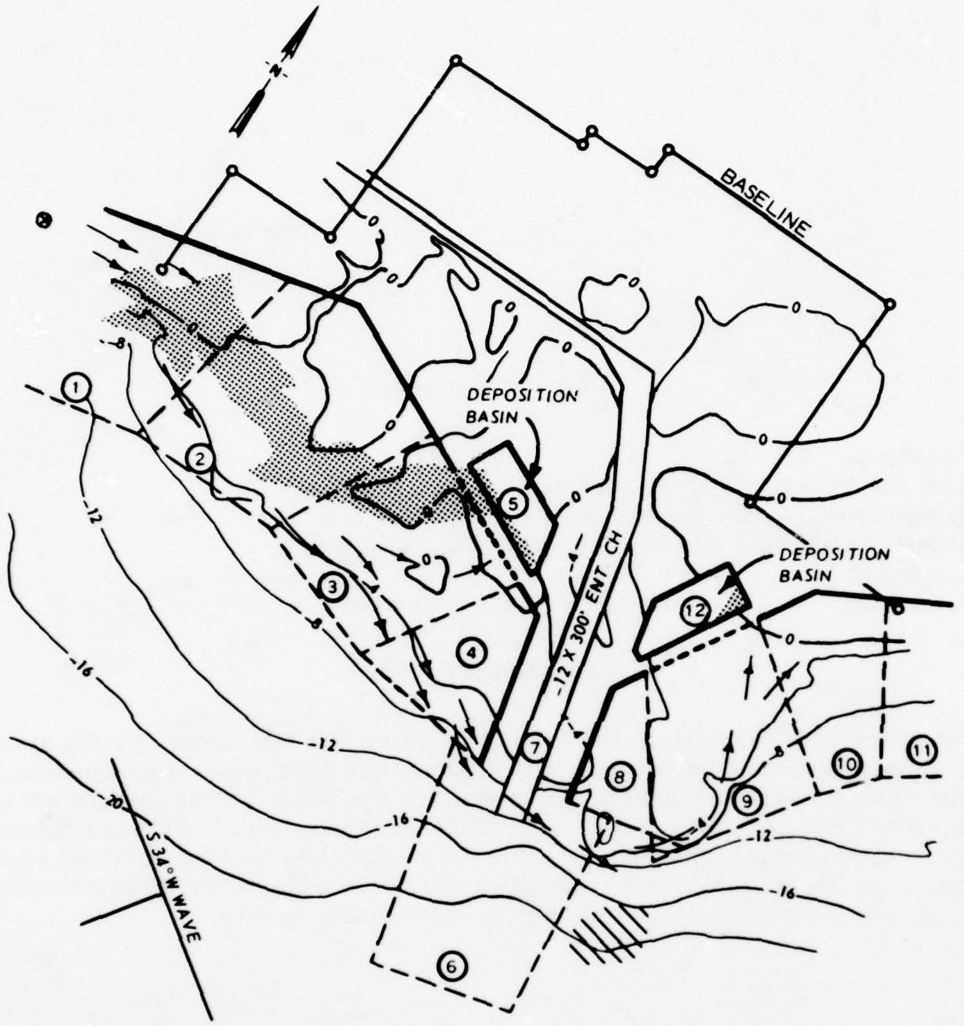
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S34°W, Height—5 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Injection at Location West of Jetties
**Duration of Test:** 8 Model Tidal Cycles
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

Conditions were similar to the previous two tests except that here the plastic tracer was injected west from the jetty system. Plate 117 shows that the tracer material generally moved in paths similar to those outlined in tests 14 and 15. Another difference from previous tests was the feeding of the west littoral zone for 8 cycles. The material built up across from the west beach to the weir jetty and most of the material was stored in Regions 1, 2, and 3. Material was fed into the west basin after moving along the buildup, and minor traces of material moved to the jetties, with the amount decreasing as the test progressed. Some of the material which bypassed the inlet deposited in the east basin, while traces deposited oceanward of Region 8.

**LITTORAL DRIFT INJECTION**
**TEST 16**




LEGEND

(1) BLOCK IDENTIFICATION NUMBER
PATH OF MATERIAL MOVEMENT
MATERIAL LOCATION AT END OF TEST
TRACES OF MATERIAL
POINT OF MATERIAL INSERTION

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

LITTORAL DRIFT
INJECTION STUDY
TEST 16

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

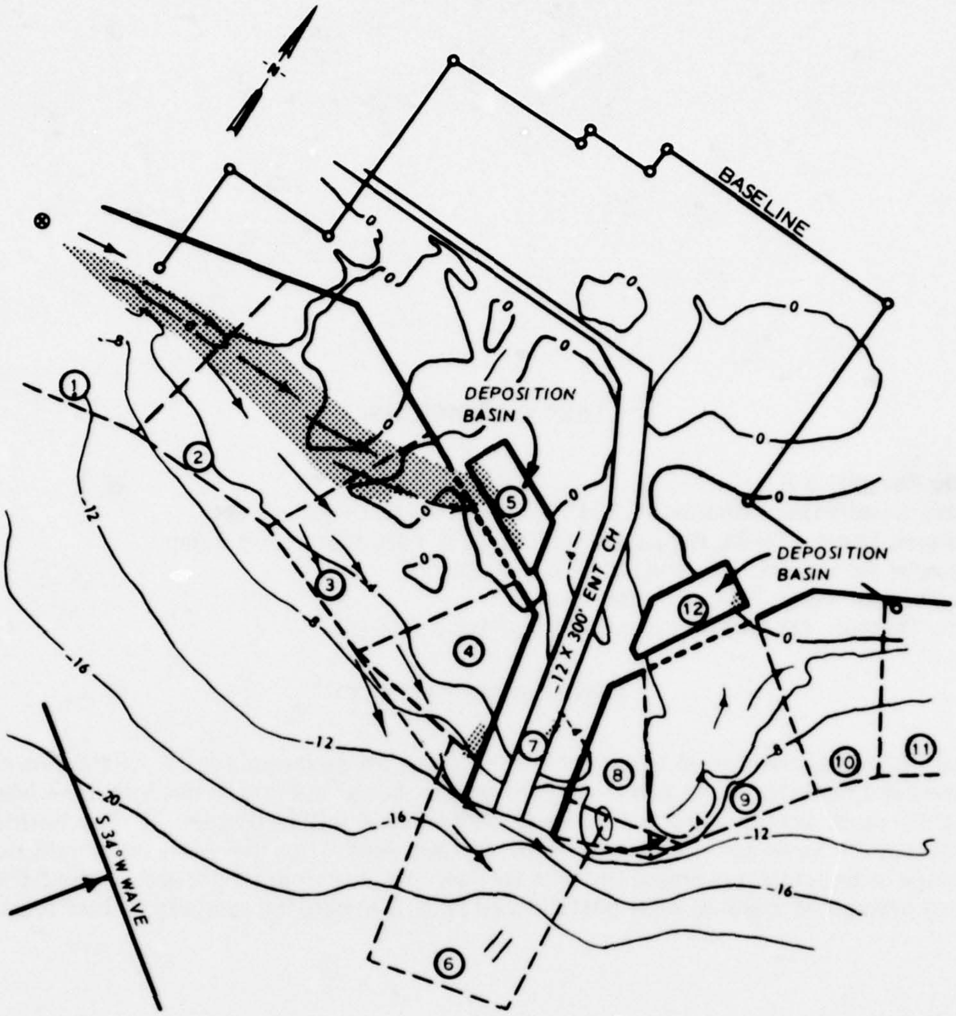
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S34°W, Height—5 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Injection at Location West of Jetties
**Duration of Test:** 2 Model Tidal Cycles
**Plan Tested:** 2D (Jetties extend to the -12 ft contour)

## DISCUSSION OF TEST

The jetties were extended to the -12 ft contour for this test. Otherwise, the same conditions were run as those run in test 16 except that the test was concluded after 2 tidal cycles of feeding. Therefore, this test can be compared with the previous test to note the difference between using the longer and shorter jetties. It was found that the results of this test were generally similar to the previous one. Most material built a bar toward the east deposition basin, and traces of material bypassed the jetties with small traces entering the channel but moving out with the ebb currents.

**LITTORAL DRIFT INJECTION**
**TEST 17**




LEGEND

- ① BLOCK IDENTIFICATION NUMBER
- PATH OF MATERIAL MOVEMENT
- MATERIAL LOCATION AT END OF TEST
- TRACES OF MATERIAL
- POINT OF MATERIAL INSERTION

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

LITTORAL DRIFT INJECTION STUDY

TEST 17

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

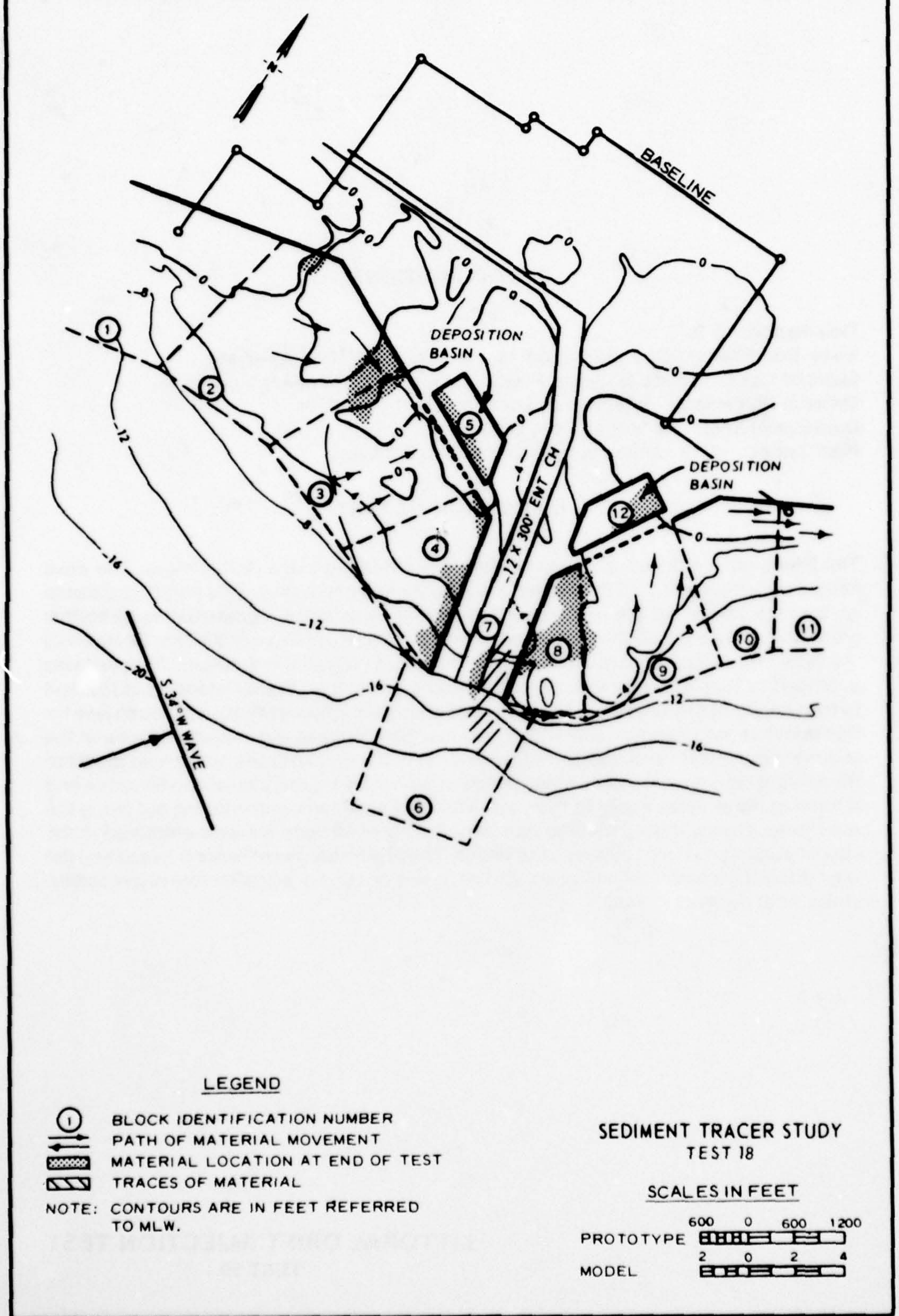
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S34°W, Height—5 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Regions 2, 3, 4, 8, 9, and 10
**Duration of Test:** 6 Model Tidal Cycles
**Plan Tested:** 2D (Jetties extend to the -12 ft contour)

## DISCUSSION OF TEST

This test was similar to test 14 except that the jetties were extended to the -12 ft contour. Movement patterns of the two tests were similar, but at the end of this test there was slightly more accumulation of material between the jetties (Region 7). The basins collected the same amount of material for the two tests. Thus there was essentially no change in sediment movement patterns between the shorter or longer jetties. About the same amount of material went past the west jetty tip toward the east jetty for both tests.

**SEDIMENT TRACER TEST**
**TEST 18**




SEDIMENT TRACER STUDY
TEST 18

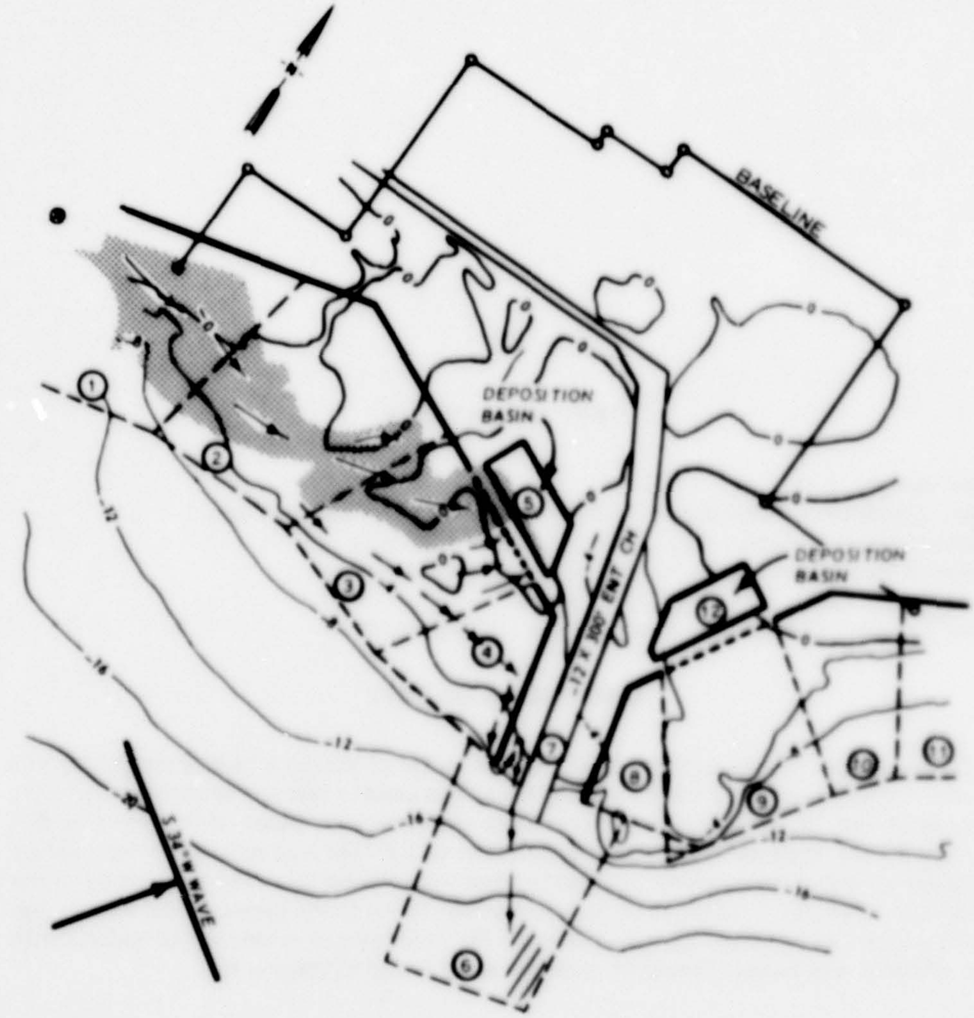
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S34°W, Height—2.5 ft, Period—7 sec
**Material Used:** Tenite Butyrate Plastic, S.G. = 1.18, Diameter = 3 mm
**Material Placement:** Injection at Location West of Jetties
**Duration of Test:** 18 Model Tidal Cycles
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

The jetties were reduced in length so that they extended to the -8 ft contour. The wave height was reduced to 2.5 ft, one half the height used previously. This height is close to an average height for the region, so that this test was more representative of normal conditions, while the higher wave represented more stormlike conditions. Because of the slow rate of sediment movement with this wave height, the duration of the test was extended to 18 tidal cycles in order to determine if fillet from Waiter Island would extend to the vicinity of the west weir. Movement of material to the west jetty was much less for this test than for previous tests with the higher S34°W wave. An important factor in the sediment movement was related to the location of the breaker zone, which was closer to the weirs for this smaller wave. Most of the longshore transport occurred in this zone and tended to move more easily to the weir, with only small amounts moving out along the west jetty, usually during the ebb tide period. Traces of material were entrained in the ebb jet coming out from between the jetties. The region between the west beach and the west deposition basin were filled in; and once this occurred, a greater rate of deposition in the west basin occurred.

**LITTORAL DRIFT INJECTION TEST**
**TEST 19**




LEGEND

BLOCK IDENTIFICATION NUMBER
PATH OF MATERIAL MOVEMENT
MATERIAL LOCATION AT END OF TEST
TRACES OF MATERIAL
POINT OF MATERIAL INSERTION

NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

LITTORAL DRIFT
INJECTION STUDY
TEST 19

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4

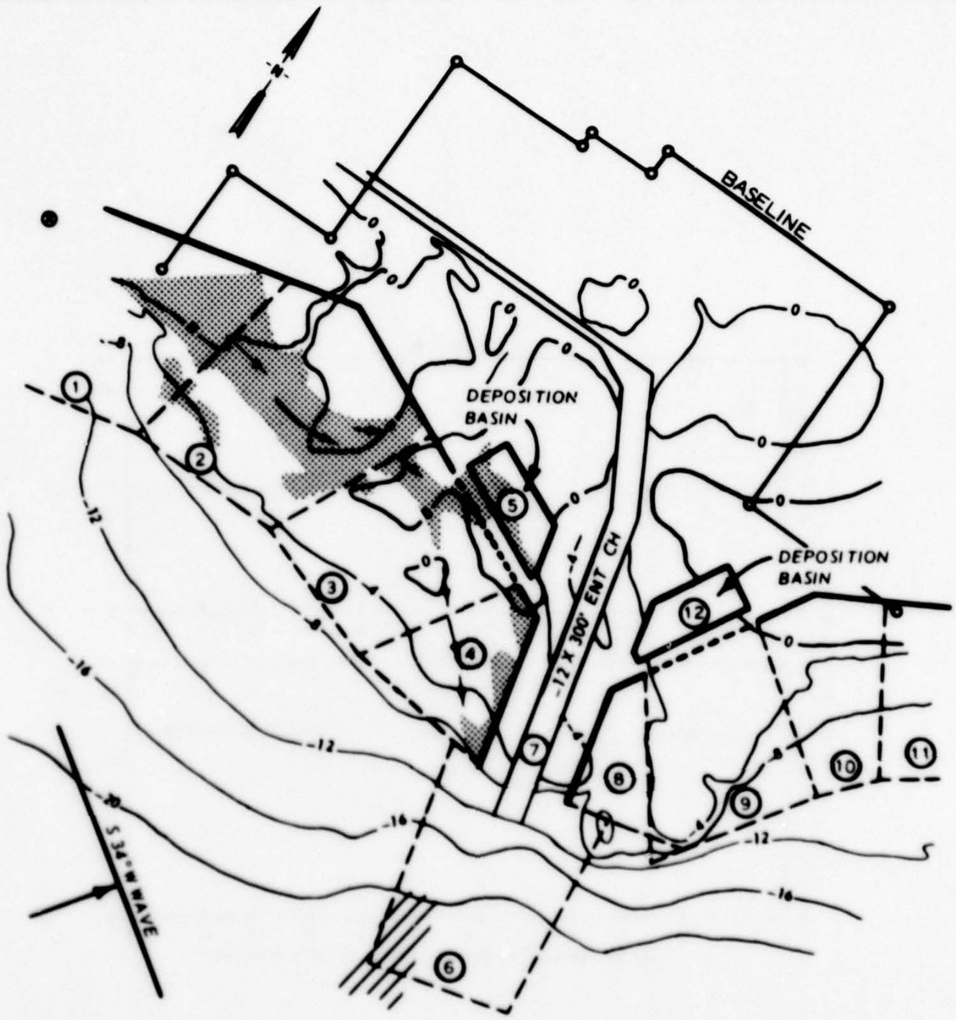
## TEST CONDITIONS

**Tide Range:** 5 ft
**Wave Conditions:** Direction—S34°W, Height—2.5 ft, Period—7 sec
**Material Used:** Plastic, S.G. = 1.05, Diameter = 2.5 mm
**Material Placement:** Injection at Location West of Jetties
**Duration of Test:** 14 Model Tidal Cycles
**Plan Tested:** 2D1 (Jetties extend to the -8 ft contour)

## DISCUSSION OF TEST

A lighter weight plastic which was within the range of scaled size and weight for this model (as determined by Yalin's scaling laws) was used in this test to compare with the results of test 19. Thus the conditions were identical with those of the previous test except for the material used and the duration of the test was reduced 4 tidal cycles because of less time required for fillet to form from Waiter Island to the vicinity of the west weir. Movement patterns of the tracer were similar to the previous test except that there was more transport into the west basin. No bypassing or movement of material into the channel was noted. Traces of material were found in Region 6.

**LITTORAL DRIFT INJECTION TEST**
**TEST 20**




LEGEND

| | |
|---|---|
| ① | BLOCK IDENTIFICATION NUMBER |
| | PATH OF MATERIAL MOVEMENT |
| | MATERIAL LOCATION AT END OF TEST |
| | TRACES OF MATERIAL |
| ● | POINT OF MATERIAL INSERTION |

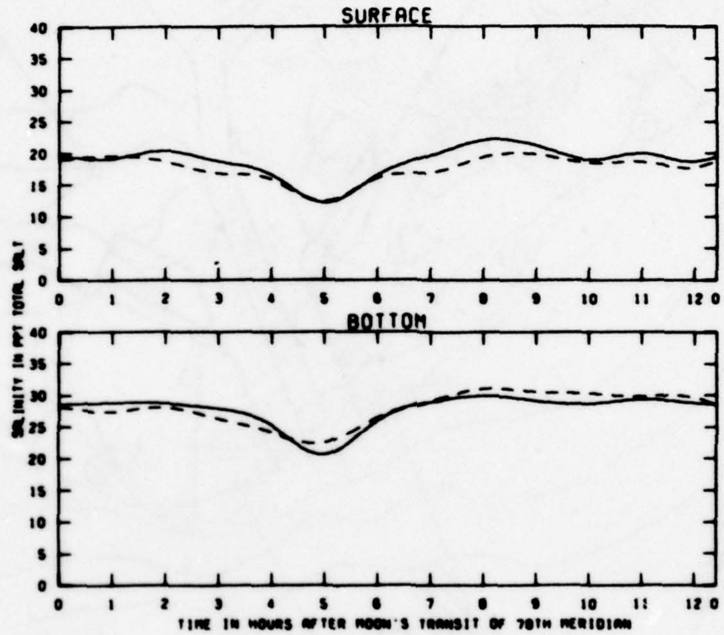
NOTE: CONTOURS ARE IN FEET REFERRED TO MLW.

LITTORAL DRIFT
INJECTION STUDY
TEST 20

SCALES IN FEET

PROTOTYPE 600 0 600 1200

MODEL 2 0 2 4




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

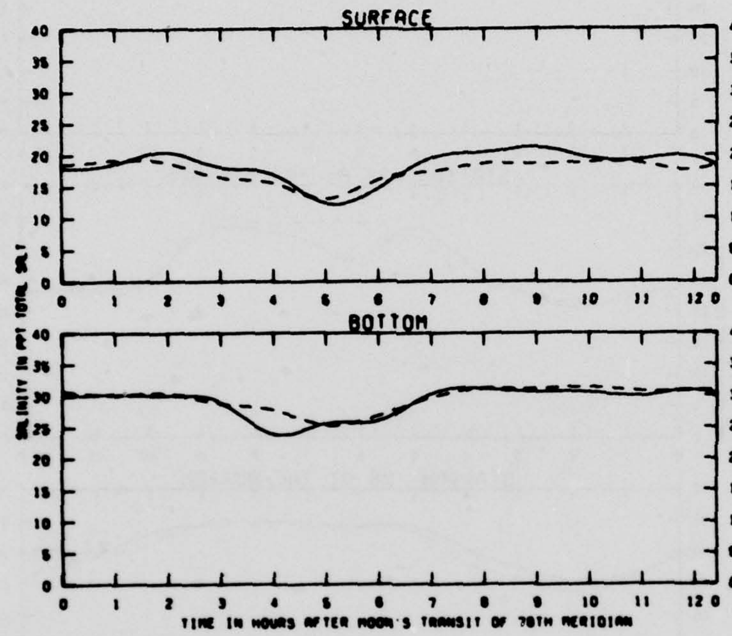
**LEGEND**

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES

STATION
1A




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

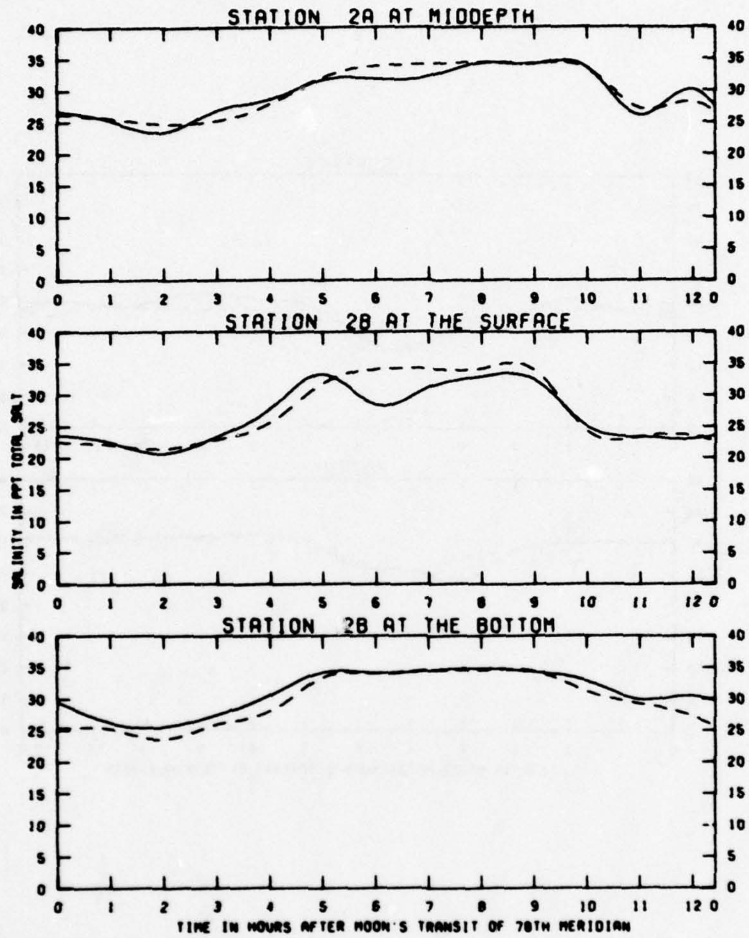
LEGEND

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1 ON SALINITIES

STATION 1B




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

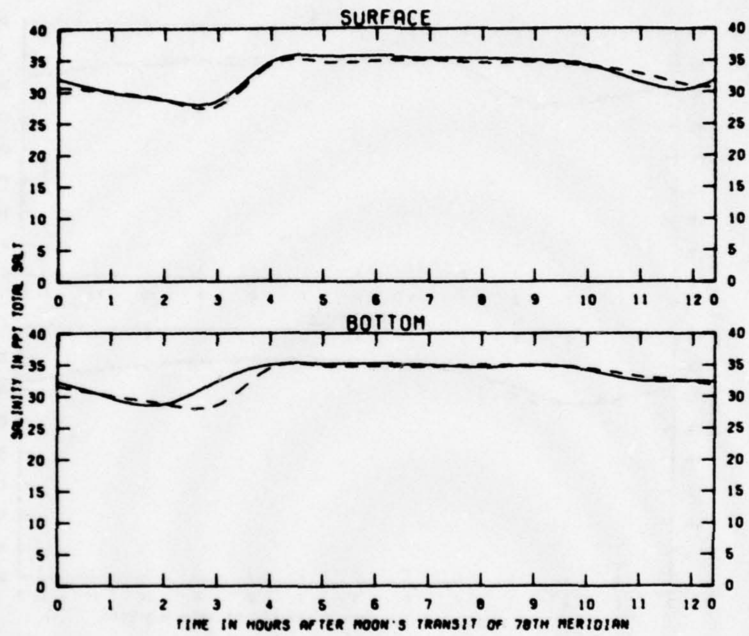
**LEGEND**

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES

STATION
2A, 2B, AND 2B




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

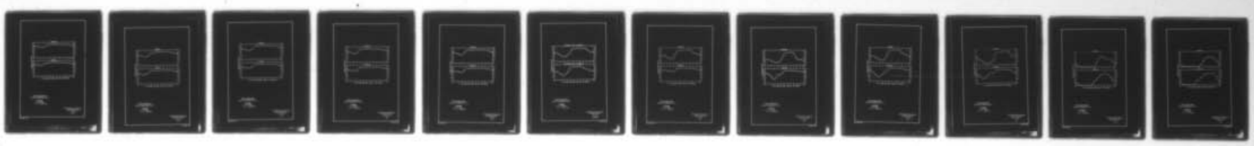
- - - - PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES

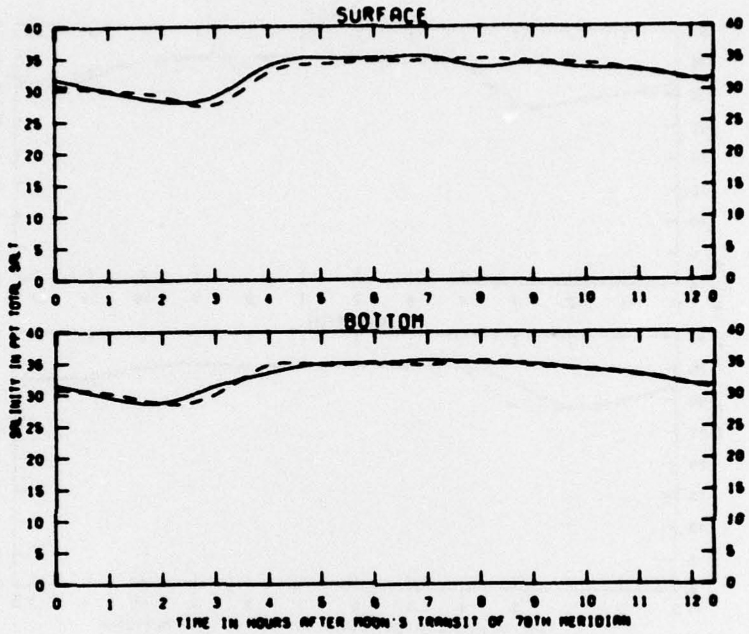
STATION
3A

AD-A049 639 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 8/3
IMPROVEMENTS FOR LITTLE RIVER INLET SOUTH CAROLINA. HYDRAULIC M--ETC(U)
NOV 77 W C SEABERGH, E F LANE
UNCLASSIFIED WES-TR-H-77-21 NL

4 OF 4
ADA049 639



END
DATE
FILMED
3 -78
DDC




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

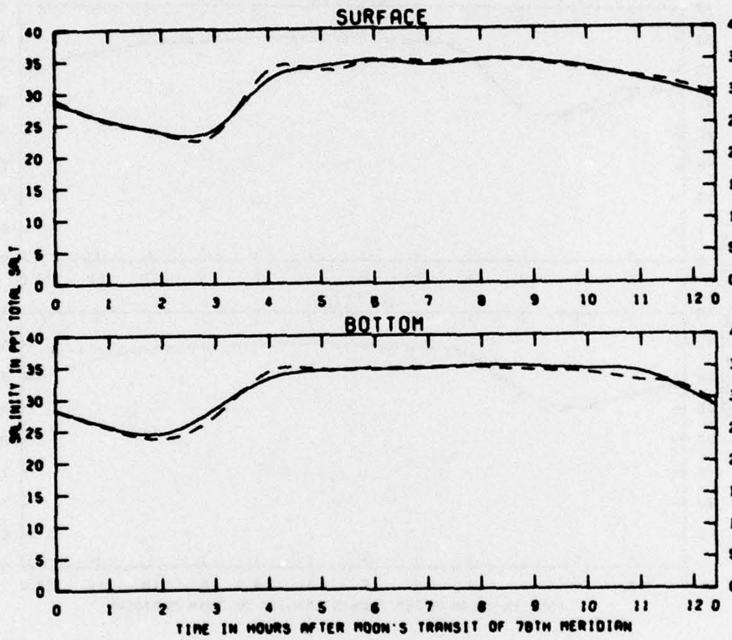
LEGEND

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES

STATION
3B




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

LEGEND

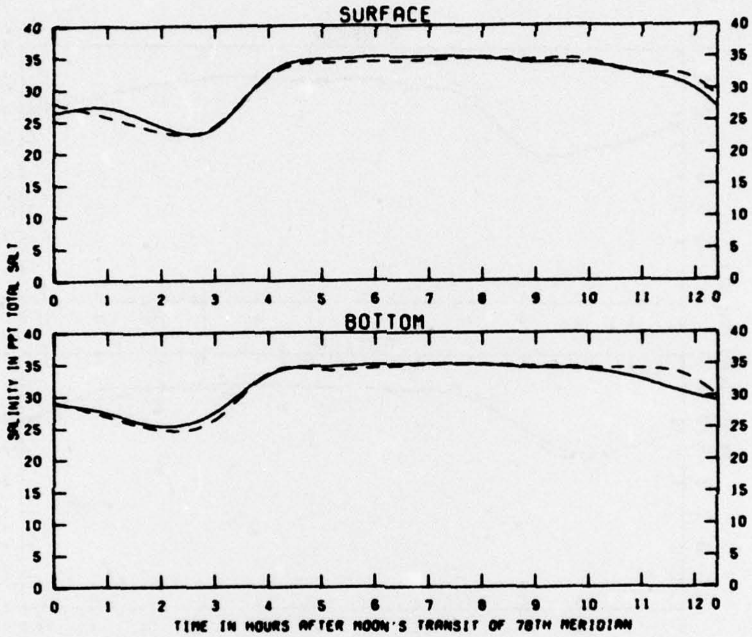
——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1 ON SALINITIES

STATION

3C




TEST CONDITIONS

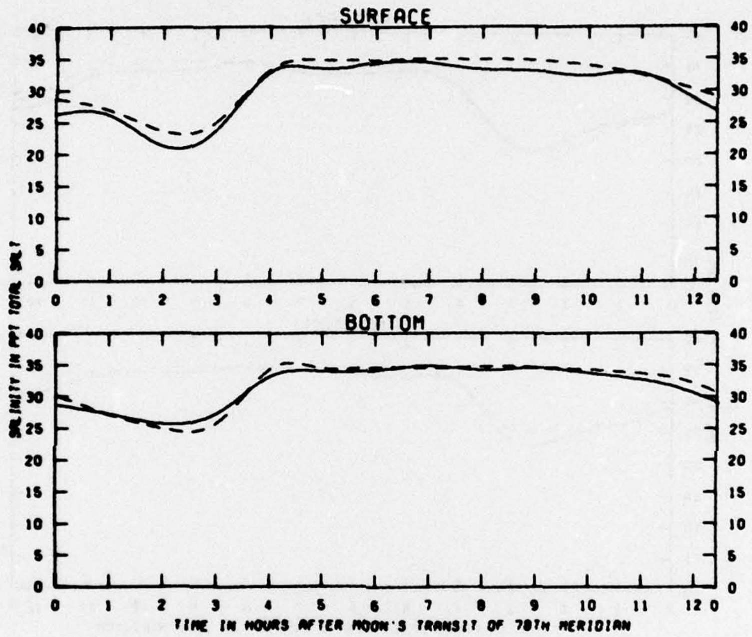
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES
STATION
4A




**TEST CONDITIONS**

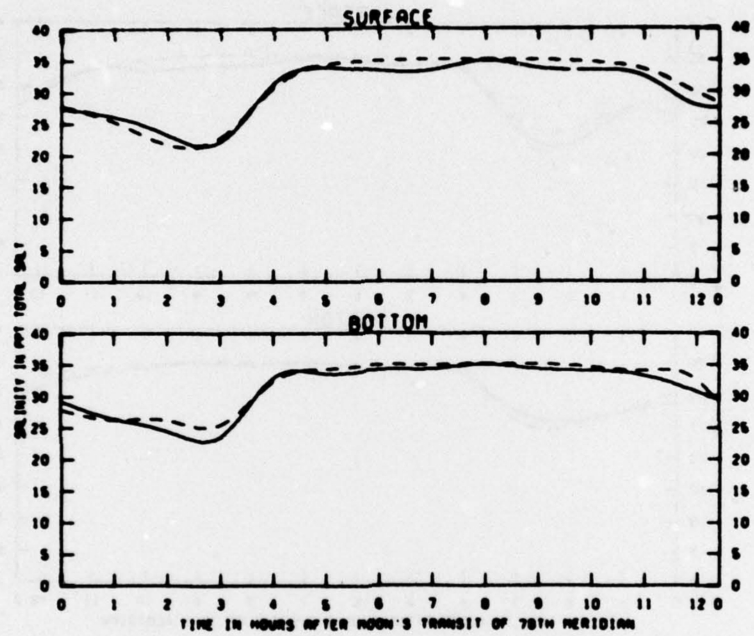
OCEAN TIDE RANGE = 5.0 FT

**LEGEND**

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES
STATION
4B




**TEST CONDITIONS**

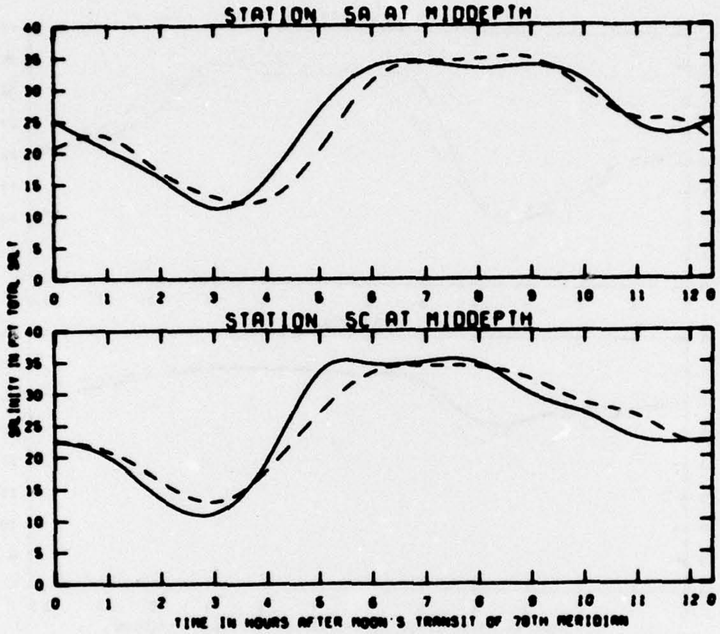
OCEAN TIDE RANGE = 5.0 FT

**LEGEND**

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES
STATION
4C




**TEST CONDITIONS**

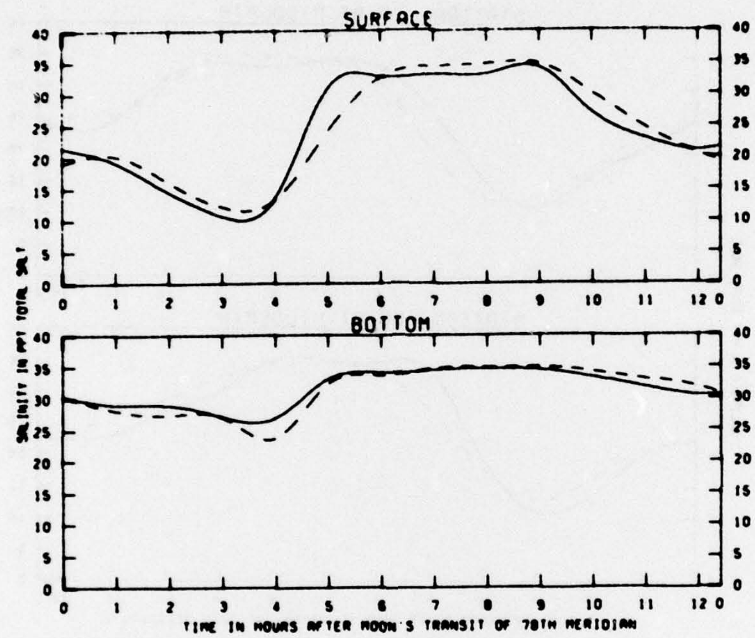
OCEAN TIDE RANGE = 5.0 FT

**LEGEND**

——— BASE

- - - - PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES
STATION
5A AND 5C




**TEST CONDITIONS**

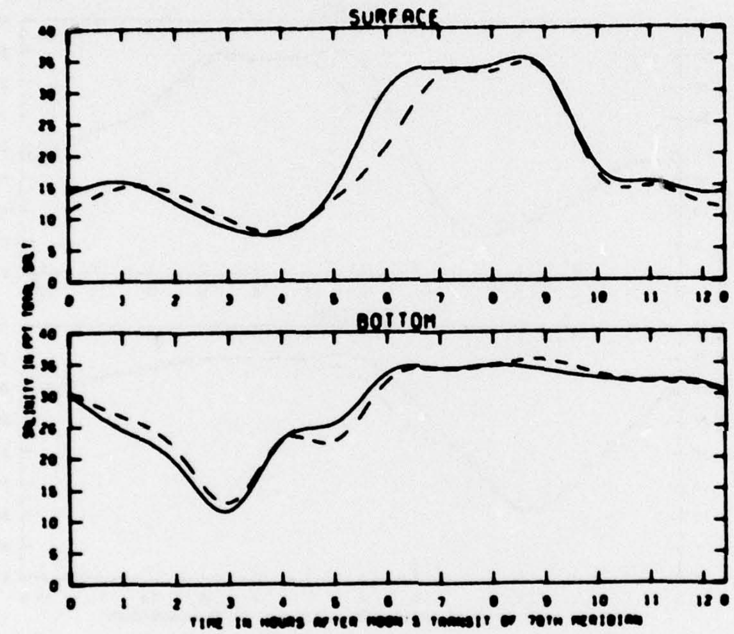
OCEAN TIDE RANGE = 5.0 FT

**LEGEND**

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES
STATION
5B




**TEST CONDITIONS**

OCEAN TIDE RANGE = 5.0 FT

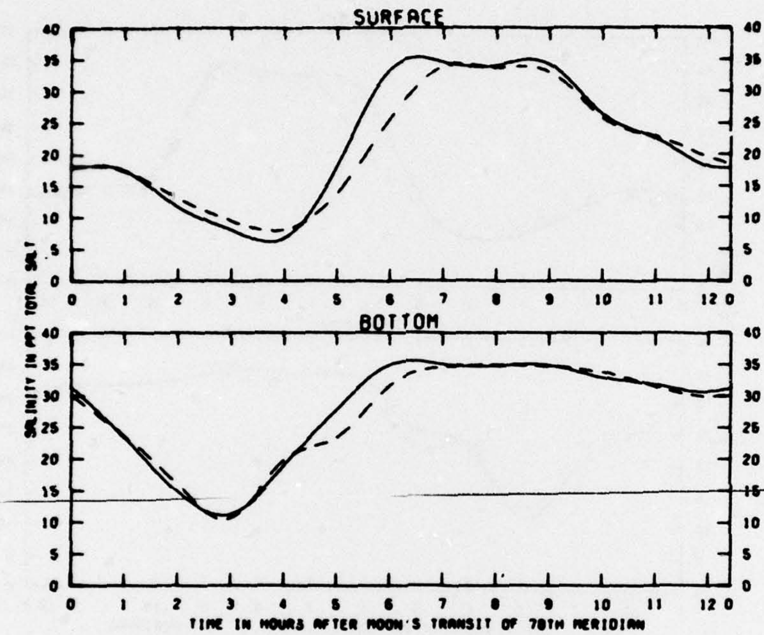
**LEGEND**

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES

STATION
6A




**TEST CONDITIONS**

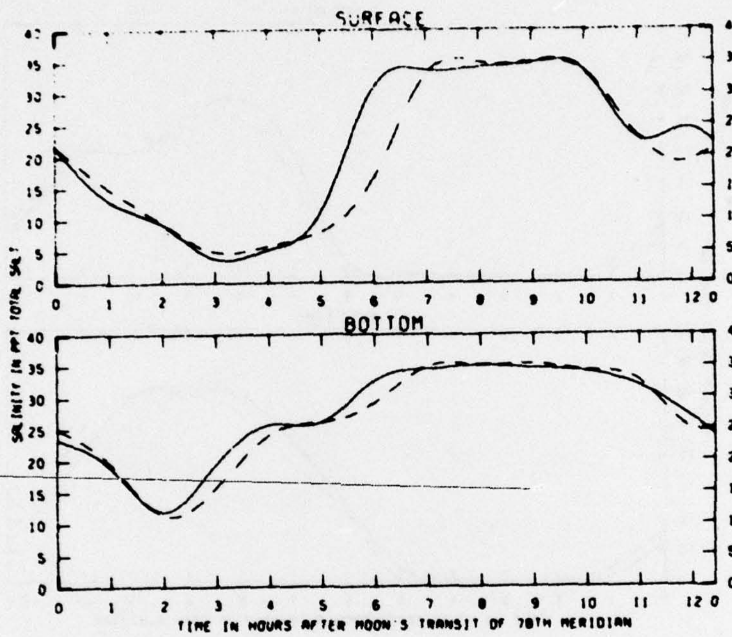
OCEAN TIDE RANGE = 5.0 FT

**LEGEND**

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES
STATION
6B




**TEST CONDITIONS**

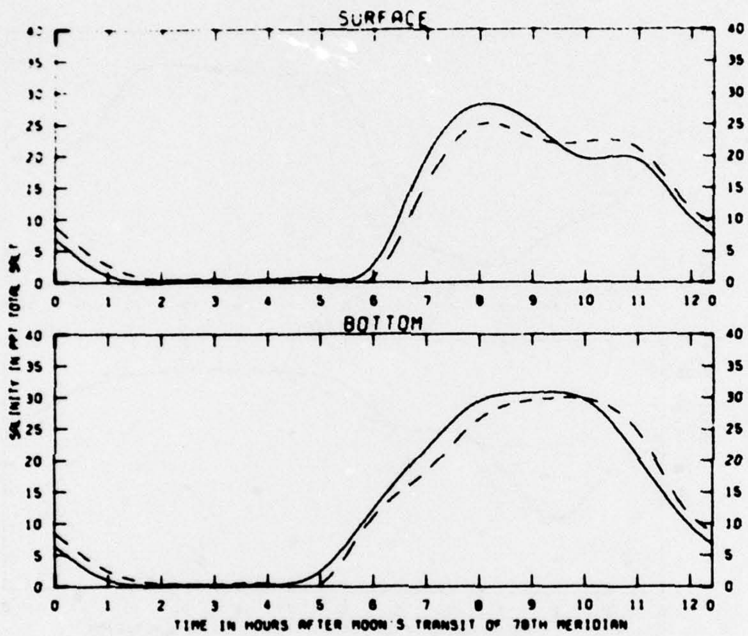
OCEAN TIDE RANGE = 5.0 FT

**LEGEND**

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES
STATION
6C




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

LEGEND

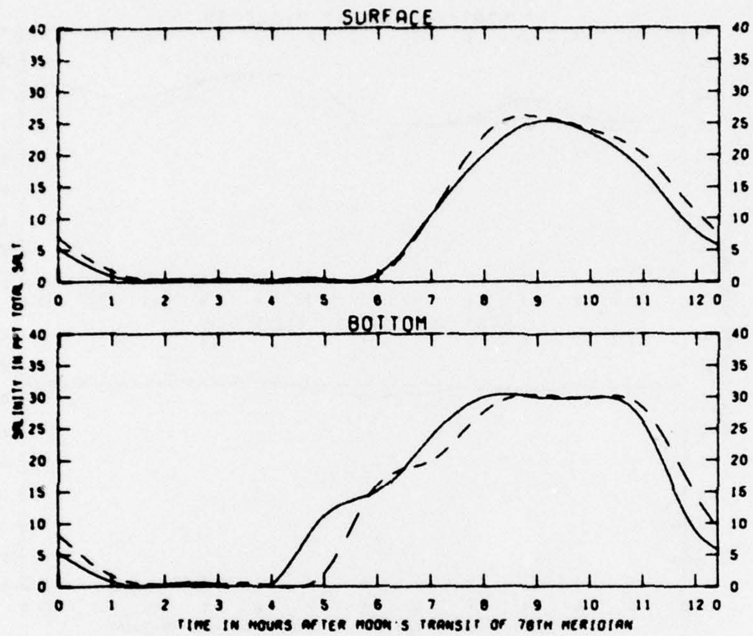
——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES

STATION

7A




TEST CONDITIONS

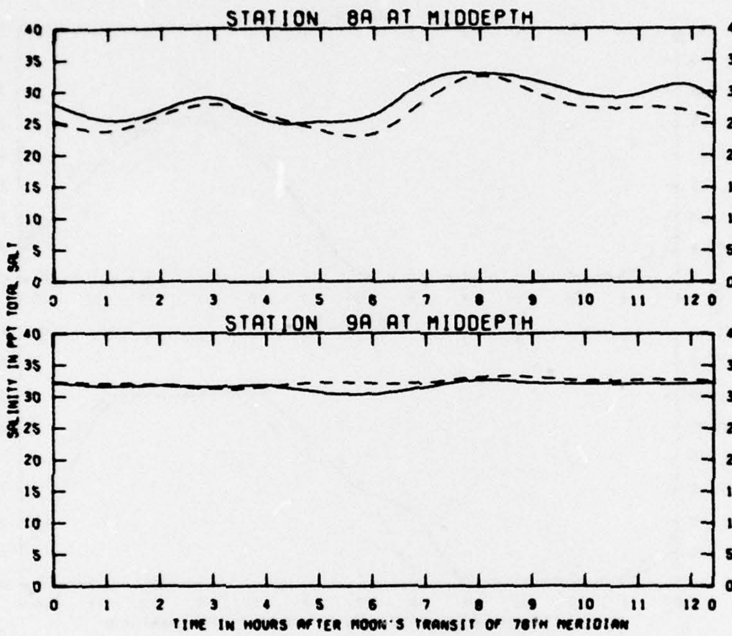
OCEAN TIDE RANGE = 5.0 FT

LEGEND

——— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES
STATION
7B




TEST CONDITIONS

OCEAN TIDE RANGE = 5.0 FT

LEGEND

———— BASE

– – – – PLAN 2D1

EFFECTS OF PLAN 2D1
ON SALINITIES

STATION

8A AND 9A

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.


Seabergh, William C
Improvements for Little River Inlet, South Carolina; hydraulic model investigation / by William C. Seabergh, Edgar F. Lane. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1977.
83, ⌊73⌋ p., 142 leaves of plates : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; H-77-21)
Prepared for U. S. Army Engineer District, Charleston, Charleston, South Carolina.
References: p. 83.

1. Channel improvement. 2. Fixed-bed model. 3. Hydraulic models. 4. Little River Inlet. 5. Tidal inlets. I. Lane, Edgar F., joint author. II. United States. Army. Corps of Engineers. Charleston District. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; H-77-21.
TA7.W34 no.H-77-21